

**SANITARY SURVEY OF THE WHIPPANY RIVER BASIN
TO EVALUATE IT'S SANITARY QUALITY AND TO
IDENTIFY NON-POINT SOURCES OF CONTAMINATION**

FINAL REPORT

June 30, 2004

WHIPPANY RIVER BASIN

NJDEP WATERSHED MANAGEMENT AREA 6

Project Officer:
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Project Name: Sanitary Survey of the Whippany River Basin to Evaluate its Sanitary Quality and Identify Non-Point Sources of Contamination.

Project Officer and Contact Person:

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Whippany, New Jersey 07981

Date of Project Initiation: 1/1/01

Date of Final Report: 6/30/04

1) Project Description (Objectives and Scope):

In a report prepared by the Whippany River Watershed Technical Advisory Committee titled "Whippany River Watershed Project Water Quality Analysis Plan (June 1994)" focus was placed on the Upper Whippany sub-watershed. Historical data shows that this sub-watershed is experiencing problems due to nonpoint source pollution. As per this report, "the focus in this sub-watershed will be on nonpoint source pollution, including fecal coliform."

Historical fecal coliform data from the upper reaches of the Whippany River show that on frequent occasions, mostly after storm events, the sanitary quality of the Whippany River significantly decreases. The Whippany River Watershed Project Technical Advisory Committee had been made aware of this data and had suggested that further studies be conducted in this area to evaluate current conditions and determine existing sources.

As part of the Whippany River Watershed Project, Storm Event Water Quality sampling was conducted on November 8-9, 1996, April 12, 1997, July 9, 1997 and June 12, 1998 by Killam Associates. Reports generated indicate elevated levels of both fecal coliform and enterococcus in runoff during storm events.

New Jersey, in 1998, had listed fecal coliform as a Section 303(d) Known Water Quality Impairment for the Whippany River. The potential sources of the fecal coliform impairment have been identified as malfunctioning and older improperly sized septic systems, Canada Geese, pest waterfowl and other wildlife, pet waste and stormwater basins. Total Maximum Daily Loads (TMDL's) are required, under Section 303(d) of the Federal Clean Water Act, to be developed for

waterbodies that can not meet water quality standards after the implementation of technology-based effluent limitations. The State of New Jersey has proposed a TMDL for fecal coliform in the Whippany River. This proposal was published in the New Jersey Register dated Monday, August 2, 1999. As listed under the State's Short-Term Management Measure for the fecal coliform TMDL, this grant will fund a diagnostic study of fecal coliform impairment in the Whippany River Watershed.

The goal of this project is to study the non-point source contribution of fecal coliform within the Whippany River Watershed. This study evaluated the sanitary quality of the Whippany River and attempted to identify and/or verify sources of fecal contamination (as mentioned above). Wet and dry weather samples were collected over a three year period at a number of locations throughout the Watershed. The initial sample locations were determined after Task A4 (mentioned below) had been completed. Areas such as bathing beaches and stormwater detention basins when found were given priority as potential areas for sampling. Additional sample locations were selected after the initial sampling data was collected and analyzed. This was done in an effort to further define the extent of fecal contamination and to identify it's source.

Samples were analyzed for various types of fecal indicators (i.e. fecal coliform, enterococcus, fecal streptococcus, E. coli) in an attempt to identify non-point sources within the Whippany River Watershed. An attempt was made to study the fecal indicators and evaluate their sanitary significance within the Whippany.

2) The project objectives are as follows:

Develop a study which will evaluate the current status of the Whippany River's sanitary quality and identify non-point source fecal loadings into the watershed. This effort will include:

- a) Review of historical data.
- b) Field survey to identify potential non-point sources of contamination.
- c) Record survey to identify known potential sources of contamination.
- d) Delineation and description of the watershed as it applies to potential sources of fecal contamination.
- e) Identify sampling station locations and develop a sampling plan.
- f) Sample stations under both dry weather and wet weather conditions to establish current sanitary quality.
- g) Conduct additional sampling to further investigate and/or identify potential sources.

- h) Attempt to quantify the impact from an identified source.
- i) Recommendations, if necessary, on best management practices (BMP's) which would reduce the fecal loading to the river.

3) The following parameters were analyzed:

- a) fecal coliform
- b) fecal streptococcus
- c) enterococcus
- d) E. coli
- e) selected fecal-oral pathogens

4) The following is a listing of the tasks performed during this project:

Task A1: Define the sub-basin to be studied.

Task A2: Review any historical data relating to the sanitary quality of the Whippany River and its tributaries.

Task A3: Review recent research work conducted on indicator organisms (fecal contamination) and reservoirs of fecal-oral pathogens.

Task A4: Conduct field survey to determine sampling stations and to identify potential non-point sources of fecal contamination and locate same using global positioning satellite system technology.

Task A5: Develop sampling plan for wet weather and dry weather sampling. Eleven (11) river stations are estimated for both the wet weather and dry weather sampling runs. Three (3) sampling runs are estimated for wet weather conditions and two (2) sampling runs are estimated for dry weather conditions. The need for additional sampling runs will be determined as data is received and after a deductive analysis of the data. The number of sampling stations during wet weather sampling is expected to increase with each sampling event (in an effort to focus in on areas of elevated fecal contamination and identify sources).

Water column samples will be analyzed by a New Jersey State certified laboratory.

Task A6: Conduct dry weather and wet weather sampling. Sampling results will be analyzed after each run and the sampling plan amended, if needed, to further investigate or verify possible sources identified during sampling.

Task A7: Conduct follow-up sampling when needed to either further identify and/or confirm a suspected source.

Task A8: Locate sampling locations using global positioning satellite system technology.

Task A9: Data Analysis and Report Preparation to include recommendations for corrective action.

All tasks will be performed jointly by Rutgers University (Department of Environmental Science) and the Township of Hanover Health Department.

Project Schedule

The total project should take approximately 3.0 years to complete. Rutgers University was contracted for one year (June 1, 2001 to May 31, 2002). The Township of Hanover Health Department began work on January 1, 2001 and anticipates that it will complete this project by June 30, 2004.

5) Description of Study Area

A detailed description of the Study area (Whippany River Watershed) can be found in "Whippany River Watershed Characterization Report" prepared by the Whippany River Watershed Characterization Committee, September 1995. The executive summary, introduction and natural features sections of this report may be found in Appendix 1. A copy of the "Whippany River Watershed Action Now Strategy of the Whippany River Watershed Management Plan" dated January 18, 2000, can also be found in Appendix 1.

Geographic Information System (GIS) maps have been constructed and placed onto a compact disk included with this report. These maps include the following features:

- New Jersey 1:24,000 scale monochromatic topographic base maps of the Whippany Watershed.
- Sampling Locations
- Water depths for some lakes
- Groundwater Recharge
- Surface contour elevations
- Land use
- Ponds, streams, river and lakes
- Whippany River Watershed municipalities and roads
- Digital orthophotography of the Whippany Watershed
- Digital photographs of the sampling locations and some of the potential sources of non-point source fecal contamination

Digital photographs and sampling data was hyperlinked to the sampling points on the above mentioned GIS sample location map.

Copies of the GIS maps generated can be found in Appendix 2. A description of the content of the compact disk can also be found in Appendix 2.

6) Methods

A method to conduct sanitary surveys of natural bathing beaches (natural waters) was developed in 1990 (Van Orden, 1990). A copy of this method can be found in Appendix 5. The methodology stated in the above mentioned work was followed during this study. An initial sampling plan was developed based upon historical data collected and the geomorphology of the Whippany Watershed. Data was analyzed after each sampling event and the findings were used to develop a sampling plan for future sampling events. Samples were collected under both dry

and wet weather conditions. Dry weather sampling was conducted to measure impacts mostly from point sources. Wet weather sampling was conducted to measure impact from both point and non-point (runoff) sources. All samples were grab samples collected using aseptic technique. Samples were collected directly into sterile 100 ml plastic sample bottles obtained from the laboratory. Samples were collected from the water column at each sampling location either by hand or by using a sampling pole (Nasco Swing Sampler). When the sampling pole was used the bottle was taped to the sample bottle holder on the pole in a manner where the bottle opening was at least two inches above the sample holder. The sampling pole was positioned (when collecting the sample) in a manner where the bottle opening when submerged was upstream of the sample pole and holder. The sample holder was disinfected prior to sampling. Samples were collected directly into the sample (bacteriological) container. At the completion of the sampling the container was sealed using aseptic technique and then refrigerated by placing sample in a cooler with ice. Sampling procedures as stated in NJDEP Field Sampling Procedures Manual (May, 1992, page 150) for bacteriology samples collected from surface waters were followed. Samples collection (date, time, location, sample container number, etc.) was recorded into a bound field book. Chain of custody forms were completed and accompanied the samples to the lab. Samples were analyzed for one or more of the following parameters:

- 1) Fecal coliform (method SM 9222D)
- 2) Fecal Streptococcus (method EPA 60087807 D)
- 3) Enterococcus (method SM 9230 C)
- 4) Escherichia coli (method SM 9221 F)
- 5) Salmonella
- 6) Shigella
- 7) E. coli O157:H7

Note: SM refers to "Standard Methods for the Examination of Water and Wastewater" prepared and published by the American Public Health Association, American Water Works Association and Water Environment Federation.

Samples were collected, refrigerated and delivered to the laboratory (Garden State Labs) within six hours of collecting the sample. All samples were analyzed by Garden State Laboratories, Inc., located in Hillside, New Jersey which is certified by the U.S. Public Health Services, New Jersey State Department of Health, New York State Department of Health - lab #11550 and the New Jersey Department of Environmental Protection - lab #20044.

During this study a fecal coliform/fecal streptococcus ratio was used in an effort to determine (understanding the error associated with this method) if the source of these indicators were possibly from human, animal or mixed fecal matter. This ratio was only used as a limited tool to assist in the investigation of a source of fecal contamination. Its use was not intended to imply any conclusion as to the origin of the fecal indicator. Its use only implies a possible source (animal or human) when sampling close to the source and when multiple sources are not involved. Historically it was believed that a fecal coliform/fecal streptococcus ratio equal to or less than 0.6 indicated a possible animal source of fecal contamination. A fecal coliform/fecal streptococcus ratio equal to or greater than 4.0 indicates possible human origin (Van Orden, 1990). "Standard Methods for the Examination of Water and Wastewater, 18th edition (1992)" later stated "*The fecal streptococcus have been used with fecal coliform to differentiate human fecal contamination from that of other warm-blooded animals. Editions of "Standard Methods" previous to the 17th suggested that the ratio of fecal coliform (FC) to fecal streptococcus (FS) could provide information about the source of contamination. A ratio greater than*

four was considered indicative of human fecal contamination, whereas a ratio of less than 0.7 was suggestive of contamination by nonhuman sources. The value of this ratio has been questioned because of variable survival rates of fecal streptococcus group species. *Streptococcus bovis* and *Streptococcus equines* die off rapidly, once exposed to aquatic environments. Whereas *Streptococcus faecalis* and *Streptococcus faecium* tend to survive longer. Furthermore, disinfection of wastewater appears to have a significant effect on the ratio of these indicators, which may result in misleading conclusions regarding the source of contamination. The ratio is affected also by the methods for enumerating fecal streptococcus. The KF membrane filter procedure has a false-positive rate ranging from 10 to 90% in marine and fresh waters. For these reasons, the FC/FS ratio cannot be recommended, and should not be used as a means of differentiating human and animal sources of pollution." For this reason the FC/FS ratio was used in this work as a limited tool only in the investigation of possible sources. The FC/FS ratio is only suggestive of a possible source for samples collected close to the source. When possible, sources in this study were verified in the field (visually) and with additional sampling. The FC/FS ratio for a sample was only used to suggest the type of source (human or animal) we were more likely to find in an area upstream and close to the respective sampling location. The Township of Hanover Health Department has used this method on numerous occasions in the past and have always been able to track, locate and visually verify either a animal and human sources of fecal contamination which corresponded to the FC/FS ratio when sampled close to the source.

7) Data

All of the raw data collected during this study can be found on the compact disk included with this report. Data was placed into Excel files and hyperlinked to the respective sampling location on the interactive GIS map (included on the disk). Summary data can be found in **Appendix 3**. The above mentioned data sets include data collected as part of this study and data collected from the following additional sources:

- Wet weather data collected by the Township of Hanover Health Department, Rutgers University and Killam Associates from 1996 thru 2001 of stormwater from a residential area within the Whippany Watershed. This work was funded by a NJDEP grant ("Improving Stormwater Runoff From A Low Density Residential Area Via An Information and Education Best Management Practice," March 15, 2002.)
- Wet weather data collected from 1996 thru 1998 by Killam Associates throughout the Whippany Watershed. This work was funded by a NJDEP grant to develop a stormwater model of the Whippany River Watershed.
- Dry weather data collected from the Whippany River and tributaries by the NJDEP during the period from 1994 thru 1995. This data was collected as part of a study to develop a dry weather model of the Whippany River.
- Dry weather data collected from the Whippany River by the Technical Advisory Committee of the Whippany River Watershed Action Committee from 2001 thru 2002. This work was funded by a Victoria Foundation Grant ("Whippany River Water Quality Trend Analysis Study," March 24, 2003).
- Dry weather data collected from Whippany Watershed lakes by the Technical Advisory Committee of the Whippany River Watershed Action Committee during 2003. This data was collected as part of a study which is currently ongoing and funded by a grant from the Victoria Foundation ("Whippany Watershed Lakes Study").
- Data (bathing beach, septic system and wildlife sources) collected from

- Health Departments throughout the Whippany River Watershed).
- Dry weather data collected by the Township of Hanover Health Department in 1986 while evaluating the sanitary quality of the Lower Whippany River and identifying a source of raw sewage to the Whippany River in Morristown.

8) Discussion

The following is a summary of the important observations that were made and reported during prior progress reports:

January 1 thru March 31, 2001

The following activities were initiated during this reporting period in an effort to better define the watershed, sources of fecal contamination within the watershed and develop a sampling plan:

- a) Initiated the development of maps for the watershed which will define its boundaries, locations for sampling, delineation of sub-watersheds which correspond to sampling locations;
- b) Obtained from Morris County digital orthophotography of the Whippany Watershed. This tool will be used to scan the watershed and identify area which may serve as potential sources of fecal contamination;
- c) Compiled existing fecal coliform and enterococcus data on the Whippany Watershed, needed to identify problem areas and include same into the sampling plan;
- d) Reviewed administrative requirements for the grant and set up a task schedule to meet the requirements;
- e) Presented this project to the newly formed Whippany River Watershed Action Committee's Technical Advisory Group (TAG) (which currently has representation by 14 out of the 16 Municipalities with the Watershed) which consists mainly of Health Officers, Registered Environmental Health Specialists and Environmental Commission Members for their input and participation. The TAG did decide to be an active participant in this work. Participation by the health officials within the Watershed would be extremely beneficial toward this work since they would have a good working knowledge of the problem areas within their jurisdictions and could be instrumental toward implementing corrective actions;
- f) The following information has been requested from members of the TAG:
 - municipal land use map (zoning) which shows sanitary sewer lines, storm sewer lines and areas of septic systems;
 - fecal coliform/enterococcus data on surface waters within the watershed (historical data)
 - list swimming areas (natural bathing areas), golf courses, playing fields (with known goose problems), wastewater treatment plants, areas where people are known to walk their pets (complaints), farms,

- livestock pens, horse stalls, ponds, areas with known deer problems on the above mentioned map;
- information mentioned above should be provided by June 1, 2001. Once this information is collected areas of concern will be identified and field visits will be scheduled.

April 1 thru June 30, 2001

- a) GeoExplorer III was purchased through state contract (#A88850). Met with Steve Jacobus (NJDEP) for a lesson on the use of the GeoExplorer III. During this period time was spent on learning about GeoExplorer III and how to operate same. A data directory for "Sanitary Survey" has been developed and loaded onto the GeoExplorer III. GPS Pathfinder Office (software to GeoExplorer III) has been set up to translate information into the State's GIS system. This unit will be field tested prior to actual data collection to assure compatibility with the State's GIS system.
- b) Garden State Laboratories, Inc., was contracted to conduct the sample analysis for this study.
- c) Based on information collected to date, started to develop a sampling plan for the initial set of both dry and wet weather samples.
- d) Started literature review on indicators in an effort to evaluate the current research in this area.

July 1 thru September 30, 2001

- a) Began collecting GPS points of sampling locations using the GeoExplorer III. This data was then transferred to the Pathfinder Office program, which was used to convert the data to an ArcView Shapefile. The shapefile of Whippany sampling locations will be used in conjunction with data from NJDEP and Morris County to create maps showing sampling locations within the Whippany Watershed.
- b) Began identifying potential sources of fecal contamination within watershed boundaries.
- c) Conducted dry weather sampling (8/9/01). The samples were then delivered to Garden State Laboratories, Inc. for analysis. Results of the initial round of sampling were received and reviewed. Additional areas for sampling were identified and included into the sampling plan for the next round of sampling.
- d) Created semi-log graphs in Microsoft Excel showing the number of indicator organisms per 100ml at each sampling location. Based on these graphs a refined sampling plan was developed.

October 1 thru December 31, 2001

- a) Collected wet weather samples on October 1, 2001. During this sampling event the conditions were as follows: rain

was light and runoff was observed from both roads and parking lots down to the storm drain system. Runoff was only observed from impervious land surfaces and not from pervious surfaces both prior to and during the sampling event.

- b) Further refined semi-log graphs in Microsoft Excel to include wet weather sampling results, and to show where the tributaries to the Whippany River reach the river and the concentration of fecal indicator detected in each during both dry and wet weather sampling. Semi-log graphs of historical data were also made to establish a comparison between past and present levels of fecal contamination. Information gained from these graphs will be used to determine the focus of maps which will be added to future reports.
- c) It was determined during this period that future sampling events should include sediments, fecal material, river banks and random soil samples from areas defined in the study.

January 1 thru March 31, 2002

- a) Conducted a number of dry weather sampling runs. During this reporting period 5 dry weather sample runs were made. The samples were then sent to Garden State Laboratories, Inc. for analysis. Samples included wildlife fecal samples, sediment samples and surface water samples. Results of the initial round of sampling were received and reviewed. Additional areas for sampling were identified and included into the sampling plan for the next round of sampling.
- b) Created semi-log graphs in Microsoft Excel showing the number of indicator organisms per 100ml at each sampling location. Sampling data is reviewed after each sample run. The ongoing sampling plan revised after each run in an effort to further investigate and define areas of concern.
- c) Sampling events during this reporting period included sediments, fecal material, and river banks samples from areas defined in the study.
- d) Sampling results to date indicate that sampling will be intensified in the following area in an effort to better define water quality and search for potential sources of fecal contamination:
 - 1. Area between Martin Luther King Blvd and Ridgedale Ave. (Morristown).
 - 2. Whippany River at Lake Road above Speedwell Lake.
 - 3. Speedwell Lake
 - 4. Burnham Pond
 - 5. Center Street outfall to Whippany River- possible mixed (human and wildlife) sources in storm drain system possible.
 - 6. Black Brook at Columbia Turnpike (Morris Twp.)
 - 7. Malapardis (aka Stoney Brook) Brook
 - 8. Tributary discharging to Whippany River near E. Frederick Place (Hanover Twp.)
 - 9. Tributary discharging to Whippany River near Boulevard Road (storm drain system)-

possible animal source in storm drain system.

10) West Brook Tributary

11) Tributary at Horsehill Road (Cedar Knolls)- possible human source. One human source was identified and abated.

12) Bee Meadow Pond outfall.

- e) A preliminary review of the fecal coliform, E. coli, fecal streptococcus and enterococcus indicators revealed that the fecal coliform and E. coli concentrations follow similar patterns (trends). Fecal streptococcus and enterococcus concentrations also follow similar patterns (trends). However, the fecal coliform and fecal streptococcus numbers are much greater than the E. coli and enterococcus respectively. Therefore a greater level of sensitivity may be achieved with fecal coliform and fecal strep indicators. Correlations between fecal coliform/e. coli and fecal streptococcus/enterococcus have been developed and plotted. This data may be found in **Appendix 3**. This data shows that good correlations exist for fecal coliform and e. coli. This correlation was further refined to look at dry weather and wet weather conditions separately. The data shows that during dry weather conditions a majority of the fecal coliform were not E. coli in samples with fecal coliform concentrations less than 350 organisms per 100 ml. In dry weather samples with fecal coliform greater than 350 organisms/100 ml the majority of fecal coliform are E. coli. Under wet weather conditions almost 100% of the fecal coliform are E. coli.

The correlation between fecal streptococcus and enterococcus is poor (scattered).

- f) Samples from the tributary at E. Frederick Place (Cedar Knolls) were elevated (fecal indicators) indicating mixed source (human and animal). This tributary was sampled further upstream near Horsehill Road (Cedar Knolls) with results strongly indicating human source. Raw sewage was observed entering a storm drain (upstream) which discharges to this trib above Horsehill Road. Sewer line from a building on Saddle Road was blocked causing sewage to back up and out of a control manhole and trickle into the storm drain. This condition was corrected immediately and the discharge was discontinued. Resampling of trib at Horsehill Road still shows elevated numbers of indicators (human source). Hanover Sewerage Authority will check their sewer line in this area to determine if it is leaking into the trib. More follow-up is needed in this area to identify a suspected source.
- g) A mixed source is suspected in the Center Street (Morristown) storm drain system. More follow-up is needed in this area. The

source of this water is Burnham Pond. The outfall of Burnham Pond has good water quality. The outfall of Burnham Pond goes underground (at Route 124) and into a storm drain collection system (which is part of the Morristown stormwater collection system) which discharges to the Whippany River at Center Street. Data collected to date indicates that fecal coliform and fecal strep are being introduced (under dry weather condition) into this collection system from unknown sources. See table below for data collected to date at this site (numbers are in organisms per 100 ml):

<u>Date</u>	Burnham Pond Outfall		Center Street Outfall	
	<u>FC</u>	<u>FS</u>	<u>FC</u>	<u>FS</u>
1/6/02	<10	30	620	380
2/12/02	20	<10	840	390
2/26/02	10	<10	890	800

- h) During January and February 2002, the number of geese around Speedwell Lake was greatly reduced when compared to other times of the year. Thin layer of ice observed on the lake during this time. Absence of goose droppings on the ground during this time when compared to the prior summer and fall where a large number of goose droppings were observed around the shore area.
- i) Trib from storm drain (groundwater base flow) which discharges under Boulevard Road (Cedar Knolls) and into Whippany River sporadically showing elevations of fecal coliform and fecal strep (indicating possible animal source). Source may be from animals which have been observed by residents living in the storm drain collection system (raccoons and cats). This area is all sewered. The sanitary sewerage system was functioning properly (as verified by the Hanover Sewerage Authority) during the time of this study.
- j) Sampling at West Brook also indicates possible mixed source (human and animals). Further investigation is needed in this area.
- k) Sediments were collected and analyzed during this time to evaluate their potential as a source of indicators. Data collected during this reporting period can be found in the following table (units are in organisms per gram):

Date	Sediment Location	FC	E.coli	FS	Enteroc.
2/19/02	River Bank-Lake Valley Rd.	<10	<10	150	40
2/19/02	Mendham-River Bed	<10	<10	30	20
2/19/02	Mendham-River Bank	10	10	60	20
2/19/02	Edwards Rd.-River Bank	10	10	60	20

Please note that weather conditions during 2/19/02 were dry and very cold.

April 1 thru June 30, 2002

- a. Conducted a number of dry weather and post wet weather sampling runs. During this reporting period 3 dry weather sample runs were made (4/2, 6/4 and 6/25/02), one sample run was made two days after a storm event (4/16/02) and one run was made one day after a storm event (6/13/02). The samples were sent to Garden State Laboratories, Inc. for analysis. Samples included wildlife fecal samples and surface water samples. Results of sampling were received and reviewed. Additional areas for sampling were identified and included into the sampling plan for the next round of sampling.
- b. Sampling collected to-date included sediments, fecal material, water and river banks samples from areas defined in the study.
- c. Sampling results indicate that sampling will be intensified in the following additional areas in an effort to better define water quality and search for potential sources of fecal contamination:
 - 1. Whippany River at Lake Road above Speedwell Lake.
 - 2. Trib discharging to Whippany River near Boulevard Road (storm drain system)- Possible animal source in storm drain system.
 - 3. Pipe discharge approximately 15 feet downstream of Center Street outfall - possible raw human sewage.
- d. Goose and duck activity throughout the watershed (especially in areas around ponds, lakes and parks) significantly increase during the warmer months (April, May and June) when compared to the colder months (January thru March) when water fowl activity appeared to be lower. Goose droppings (on the ground) during the colder months were sporadic in these areas. During the warmer months, goose droppings were much more numerous in the same areas.

The following important observations were made during this reporting period:

- a. Environmental conditions (freezing and moisture content) appear to have an effect on the number of indicators present in animal feces. Data collected to date can be found in table below (units are in

organisms per gram):

<u>Date</u>	<u>Animal Source</u>	<u>Condition</u>	<u>FC</u>	<u>E. coli</u>	<u>FS</u>	<u>Entero</u>
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10/1/01	Goose	Fresh	53,000	53,000	lab error	440,000
1/16/02	Goose	Fresh-Frozen	27,000	27,000	270	20
2/12/02	Goose	Fresh-Frozen	40	10	<10	<10
2/12/02	Goose	Fresh-Frozen	40	40	30	20
2/19/02	Deer	Fresh-Frozen	<10	<10	100	70
2/26/02	Goose	Fresh	2,400	2,400	210	110
2/26/02	Goose	Fresh	2,800	2,300	520,000,000	400,000,000
3/12/02	Goose	Fresh	9,600	9,600	14,000	13,000
3/12/02	Goose	Old Semi-Dry	14	14	58	<16
3/12/02	Goose	Old Dry	<29	<29	2900	2400
4/16/02	Goose	fresh	31,000	31,000	3,400,000	1,800,000
6/4/02	Goose	Fresh	6,800	6,400	4,000	3,000
6/13/02	Goose	Fresh	2,400,000	2,200,000	59,000,000	46,000,000
6/13/02	Dog	Fresh	3,900,000	3,300,000	>200,000,000	43,000
6/13/02	Goose	Fresh	420,000	390,000	930,000	660,000

Based on the limited data collected, Freezing and low water activity (dryness) appear to have a negative impact on the indicator organisms in animal feces. Organisms appear to die off quickly when fecal matter is frozen or dry. Further studies are needed to prove this hypothesis.

b. A mixed source is suspected in the Center Street (Morristown) storm drain system. More follow-up is needed in this area. The source of this water is Burnham Pond. The outfall of Burnham Pond has good water quality. Outfall of Burnham Pond goes underground through a storm drain collection system (under Morristown) and discharges to the Whippany River at Center Street. Fecal coliform and fecal strep are being introduced (dry weather condition) somewhere in this collection system. See table below for data collected to date at this site (numbers are in organisms per 100 ml):

<u>Date</u>	Burnham Pond Outfall		Center Street Outfall	
	<u>FC</u>	<u>FS</u>	<u>FC</u>	<u>FS</u>
1/6/02	<10	30	620	380
2/12/02	20	<10	840	390
2/26/02	10	<10	890	800
4/16/02	60	10	6,700	10,000
6/4/02	70	30	2,400	480
6/13/02	260	130	380	210

c. Sampling at West Brook also indicates possible mixed source (human and animals). Further investigation is needed in this area. The right trib coming into West Brook seems to contain much more fecal contamination than the left trib. Ratio's indicate source to be more of animals than man.

d. A significant source of raw sewage may have been identified From a pipe approximately 15 feet downstream of the Center Street storm drain outfall. This condition has been brought

to the attention of the Morristown Health Officer for follow-up and possible enforcement. Follow-up sampling will be conducted in this area.

- e. Fecal coliform and fecal strep numbers were moderately elevated in the Whippany River one to two days after storm events.
- f. During dry weather conditions the fecal coliform and fecal strep concentrations are much lower in the Whippany River during the colder months. Concentrations do increase with the warmer seasons (temperature) which may be due to an increase in animal activity and/or possible aftergrowth of the indicator organisms.

July 1 thru September 30, 2002

Nothing new to add.

October 1 thru December 31, 2002

- a) To date the only true wet weather samples (samples collected during a rain event) were collected on October 1, 2001 and November 6, 2002. During the October 1, 2001 sampling event the conditions were as follows: the rain was light and runoff was observed from both roads and parking lots down to the storm drain system. Runoff was only observed from impervious land surfaces and not from pervious surfaces both prior to and during the sampling event. During the November 6, 2002 sampling event the conditions were as follows: Heavy rain occurred (after a sufficient dry weather period) during the early morning hours (after midnight) and sampling occurred during the mid to late morning. Weather conditions during sampling were cloudy and windy with sprinkles.

WET WEATHER SAMPLING
11/06/02
CONCENTRATION IN #/100 ml

<u>SAMPLE LOCATION</u>	<u>FC</u>	<u>FS</u>	<u>FC/FS</u>
Sunrise Lake	<10	30	0.3
Burnham Pond	20	<10	2.0
Harmony Brook	60	1900	0.03
Dismal Brook	120	460	0.26
Washington Valley Rd. trib	150	2300	0.065
Gillespie Hill	160	150	1.07
Stoney Brook at Parsippany Rd.	220	870	0.25
Whippany River at Tingley Rd.	340	1200	0.28
Tingley Rd. Ditch	460	670	0.69

Continued

<u>SAMPLE LOCATION</u>	<u>FC</u>	<u>FS</u>	<u>FC/FS</u>
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Whippany River at Whitehead Rd.	490	930	0.53
West Brook (left)	570	430	1.33
Center Street Outfall	570	950	0.6
Gaston Road Trib.	680	2000	0.34
Whippany River at Mendham Munic.	950	3400	0.28
Trib A at Lake/Ketch	1000	3700	0.27
Horsehill Rd. Trib.	1200	4100	0.29
Troy Brook	1700	4000	0.43
Trib at Whitehead Road	1900	12000	0.16
Whippany River at Parsippany Rd.	2100	2800	0.75
West Brook (right)	2200	2800	0.79
Whippany River at Center Street	2200	870	2.52
Whippany River at Melanie Lane	2300	7900	0.29
Trib B at Lake/Ketch	2600	11000	0.24
Whippany River at Lake Valley Rd.	3400	10000	0.34
Watnog Brook	3700	5400	0.69
Whippany River at Edwards Rd.	4000	5800	0.69
Speedwell Lake	4400	4300	1.02

Note: Samples collected from tribs and pond outfalls which drain wooded and/or rural areas had the lowest numbers of fecal coliform with FC/FS ratios indicative of animal sources.

Samples collected from areas which drain developed areas (higher density residential) have relatively higher fecal coliform concentrations with FC/FS ratios indicative of animal sources.

- b) A significant source of raw sewage may have been identified from a pipe located approximately 15 feet downstream of the Center Street storm drain outfall (this was mentioned earlier in this report). This condition had been brought to the attention of the Morristown Health Officer (Howard Steinberg) for follow-up and possible enforcement. Follow-up sampling will be conducted in this area. As per the Morristown Health Officer, this pipe was disconnected and the source eliminated (August 2002).
- c) During wet weather conditions (November 6, 2002), runoff from areas which are wooded and rural have relatively low levels of fecal contamination. Areas which are more densely populated have the highest amount of fecal contamination in the runoff. Wet weather samples from sewered areas contain higher fecal coliform and fecal strep than samples from septic areas. Sewered areas appear to be more densely populated than septic areas. Septic systems do not appear to play a significant role as a source during this time. Fecal coliform/fecal strep ratio's during wet weather strongly indicate that the source of fecal contamination may be of animal origin. Most likely the sources (which were visually observed throughout the watershed) include water fowl and other birds, pet waste, horses (observed in the rural areas of Harding, Mendham and Morris Townships) and wildlife (mainly deer, raccoons, skunks, rabbits, squirrels, ground hogs, rats, mice).

January 1 thru March 31, 2003

- a. Data was collected from a number of past and current unrelated projects. This data include dry weather samples collected during 1986, 1994, 1995, 2001 and 2002; wet weather samples collected during 1996, 1997, 1998, 2000 and 2001. Excel files were created for each of the locations within the Whippany River Watershed where data exists. GIS maps were developed for the Whippany Watershed which show sampling station locations. Each location on the map will be hyperlinked to the respective excel file. This work will continue through the completion of this project. The finished product will include a GIS map of the watershed with all station locations which will be hyperlinked to all the data (historical/current/wet weather and dry weather) for that location.
- b. Sampling at West Brook also indicates possible mixed source (human and animals). Further investigation is needed in this area. The right trib coming into West Brook seems to contain much more fecal contamination then the left trib. Ratio's indicate source to be more of animals than man.
- c. Results from Dry Weather sampling conducted on January 28, 2003, are listed below:

Whippany River Dry Weather Sampling Run
Extreme Cold Conditions
January 28, 2003

<u>Sample Location</u>	<u>FC</u>	<u>FS</u>	<u>FC/FS</u>
Mendham Twp. Municipal Bldg.	40	<10	4.0
Whippany River at Tingley Rd.	<10	<10	
Whippany River at Speedwell Ave.	210	30	7.0
Whippany River at Center St.	20	<10	2.0
Tributary at Horsehill Rd.	250	140	1.8
Whippany River at S. Jefferson Rd.	40	<10	4.0
Whippany River at Melanie Ln.	40	10	4.0
Whippany River at Edwards Rd.	60	<10	6.0

Note: Whippany River, Tributaries and ponds were frozen at many locations due to an extended period of extremely cold temperatures.

The above results reinforce the earlier findings that temperature has a definite affect on the indicators. Numbers were much lower

during extreme cold conditions which may be due to die-off (as seen with the goose droppings), less animal activity or a slower rate of aftergrowth (growth rate is a function of temperature).

- d. During 2001/2002 the Township of Hanover conducted a trend analysis study of water quality within the Whippany River. This study was funded under a grant received from the Victoria Foundation and did not include data generated under the "Sanitary Survey" work. Data collected by the Whippany Technical Advisory Committee during 2001/2002 was compared to data collected by the NJDEP during 1994/1995 (both under dry weather conditions). This study found that fecal coliform concentrations decreased from a 1994/1995 river mean of 375.2 per 100 ml to a 2001/2002 river mean of 237.4 per 100 ml. This represents a 37 % decrease in fecal coliform from 1994/1995 to 2001/2002 under dry weather conditions. The trend analysis work was independent of the Sanitary Survey work being performed under this grant.

April 1 thru June 30, 2003

- a) With the cooperation of all Health Departments within the watershed, a study of the septic system areas within the watershed was completed. Areas which are on septic systems have been listed along with those areas where problems have been documented. This data may be found in **Appendix 3**.

July 1 thru September 30, 2003

- a) Sampling was conducted throughout the watershed on August 14, 2003, to reflect post wet-weather conditions (sampling occurred the first dry day, with no stormwater runoff, after approximately 2 weeks of continuous heavy rains. Sampling was conducted throughout the watershed on August 18, 2003, which was dry weather sampling to reflect the first dry weather period after 2 weeks of continuous rains. On September 8, 2003, sampling was conducted to further identify potential sources in the areas of Saddle Road and Horsehill Road in Cedar Knolls and elevated levels observed in Watnong Brook. This data may be found in **Appendix 3**. Sunrise Lake in Mendham was also sampled (as part of a Victoria Foundation Grant to study Lakes within the Whippany River Watershed) on August 20, 2003 under dry weather conditions. The Sunrise Lake study included analyzing the Lake inputs, outputs, epilimnion, hypolimnion and sediments for fecal coliform and fecal streptococcus. Data from all the above mentioned sampling events have been included in this report and will be added (hyperlinked) to the GIS maps developed as part of this study.
- b) Data continues to be collected from current unrelated projects (Whippany River Trends Analysis Study and Whippany River Lakes Study both funded by the Victoria Foundation) and incorporated into this work. This data is being entered into the Excel files for each of the sampling stations locations within the Whippany River

Watershed. GIS maps were developed for the Whippany Watershed which show sampling or station locations. Each sample location on the map is hyperlinked to the respective Excel file. This work will continue through the completion of this project. The finished report will include a GIS map of the watershed with all station locations which will be hyperlinked to all the data (historical/current/wet weather and dry weather) for that location.

October 1 thru December 31, 2003

- a) Sampling was conducted throughout the watershed on October 27, 2003 to reflect wet-weather conditions.

SUMMARY OF OBSERVATIONS MADE DURING SAMPLING AND/OR DATA ANALYSIS

- River, lake and stream sediments may be a source of fecal coliform. Suspended solids containing bacteria (coliform) will settle out of the water column and into sediments after a storm event (as water velocities decrease). During a storm event (as water velocity increases) settled sediments could become resuspended increasing the number of coliform in the water column.
- Wildlife activity appears to be directly related to temperature. Activity increases as temperature increases.
- Fresh Animal Droppings appear to contain a significantly larger number of fecal streptococcus and enterococcus than fecal coliform and e.coli.
- Frozen (fresh) goose droppings contain significantly fewer fecal coliform, fecal streptococcus, e.coli and enterococcus when compared to the unfrozen (fresh) droppings. The freezing process may be greatly reducing (killing) the indicator organisms. Dessication also appears to have a significant negative effect on the numbers of indicators in a goose dropping.
- The number of fecal indicators appears to be greatly reduced (under dry weather conditions) during the winter months when compared to other seasons throughout the year. This may be due to the following:
 - Effect of freezing on indicator organisms in goose droppings.
 - Decrease in runoff due to frozen conditions.
 - Slower rate of aftergrowth (indicator organisms which have the ability to grow in the surface water environment would have a slower rate of growth during cold weather conditions). Growth rate is a function of temperature.
 - A decrease in wildlife activity during colder months would decrease the rate of fecal deposition into the environment from this source.
- Boulevard Road storm drain system (this area is sewerred with no known problems with the sewerage collection system as investigated and reported by the Hanover Sewerage Authority) with dry weather flow (due to groundwater base flow) contains elevated numbers of fecal streptococcus and occasional elevated fecal coliform. There have been reports from residents of raccoons living within this storm drain system. Elevated indicator numbers suggest (FC/FS ratio) animal source. This observation suggests that wildlife does live in these storm drain systems and may be

contributing to the fecal coliform and fecal streptococcus loading to these systems.

- Most of the lakes and larger ponds throughout the Whippany Watershed contain very large goose and duck (water fowl) populations. Large accumulations of goose droppings have been observed on the grounds and shorelines adjacent to these water bodies. This has been confirmed in the following areas:
 - Sunrise Lake, Mendham Twp.
 - Malapardis Pond, Hanover Township.
 - Stoney Brook Pond, Hanover Township
 - Bee Meadow Pond, Hanover Township
 - Speedwell Lake, Morristown
 - Pinchbrook Golf Course Ponds, Florham Park
 - Eden Lane Impounded Area, Hanover Township
 - Chatteau Thierry Condominium Pond, Madison
 - Old Troy Park Pond, Parsippany
 - Brookside Beach (Pond), Mendham Twp.
 - Crystal Lake, Mountain Lakes
 - Sunset Lake, Mountain Lakes
 - Wildwood Lake, Mountain Lakes
 - Mountain Lake, Mountain Lakes
 - Community Park Pond, Morris Plains
 - Watnog Pond, Morris Plains
 - Jaqui Pond, Morris Plains
 - Baker Property Pond, Morris Plains
 - Burnham Pond, Morris Township
 - Lake Interval, Parsippany
 - Knoll County Club Golf Course, Parsippany
 - Lake Parsippany, Parsippany

- Streams emerging from wooded or rural areas throughout watershed generally contain relatively lower fecal coliform under both dry and wet weather conditions. These streams usually contain less than 200 fecal coliform/100 ml under all conditions. These areas include the following:
 - Harmony Brook
 - Dismal Brook
 - Gillespie Hill Tributary
 - Sunrise Lake
 - Washington Valley Rd. Trib
 - Whippany River at Tingley Rd.
 - Whitehead Road Trib.

- Raw sewage observed discharging from a backed up sewer line on Saddle Rd. (Hanover Township) across the ground and into a storm drain system (April 2002). This storm drain system discharges into a tributary which crosses Horsehill Rd. Samples collected from this Horsehill Rd. Trib prior to this observation did have elevated levels of fecal coliform and a FC/FS ratio which indicated possible human source. This source was immediately corrected. More detailed report on this investigation may be found in **Appendix 3.**

- Raw sewage observed discharging from a pipe into the Whippany River immediately downstream of the Center Street storm drain outfall (Morristown). This information was reported to the Morristown Health Department for further investigation and action (June 2002).

- Sampling on August 14, 2003, was one day after about two weeks of wet weather (heavy rains). There was no direct runoff occurring on this date, Whippany River water looks relatively clear with some turbidity. Stream and River flow is mostly drainage from low lying (wet) areas, detention basins and high base (groundwater) flow. No runoff observed from impervious surfaces (i.e. roads, parking areas, pavement). High concentrations of tannin observed in samples collected from Black Brook, Stoney Brook, Melanie Lane, Elm Street (Florham Park) brook.. Source of tannin is most likely from wetland (meadow, marsh) areas. Significant amount of drainage observed coming from swamp areas near Edwards Road. Most of the samples collected on this day were lost at the lab (Garden State Lab) due to major blackout in the New York, New Jersey metropolitan area.
- Samples collected on August 18, 2003, after 5 days of dry weather following two weeks of heavy rain. Large number of fish observed at S. Jefferson Road station (bass, blue gills and suckers). River water is clear. Tannin still observed in samples collected from Elm Street (Florham Park) brook, Black Brook and Edwards Road (indicating that wetland and meadows are still draining).
- Wet weather sampling conducted on October 27, 2003. Area at 8 Saddle Road (Township of Hanover) was regraded and seeded eliminating the wet ditch condition. This was an area where water was collecting and laying in a ditch and where numerous goose droppings were observed. This condition was eliminated after re-grading and re-seeding. Area no longer has wet standing water and there were no goose droppings observed. See report dated Sept. 8, 2003, "Whippany River Watershed Sanitary Survey Possible Source Investigation Saddle Road (Horsehill Road Trib," located in **Appendix 3**. Still a large number of goose droppings observed on grass areas and sidewalks on Saddle Road and Horsehill Road (in this area) upstream of Horsehill Road trib sampling station.
- During wet weather sampling on October 27, 2003, illicit pipe discharging gray water into river (same pipe observed earlier during June of 2002) immediately downstream of the Center Street (Morristown) storm drain outfall - same side. Morristown's new Health Officer (Mark Colicchio) was informed of this condition for his investigation and action.
- A preliminary review of the fecal coliform, E. coli, fecal streptococcus and enterococcus indicators revealed that the fecal coliform and E.coli concentrations follow similar patterns (trends). Fecal streptococcus and enterococcus concentrations also follow similar patterns (trends). However, the fecal coliform and fecal streptococcus numbers are much greater than the E.coli and enterococcus respectively. Therefore a greater level of sensitivity may be achieved with fecal coliform and fecal strep indicators. Correlations between fecal coliform/e.coli and fecal streptococcus/enterococcus have been developed and plotted. This data may be found in **Appendix 3**. This data shows that good correlations exist for fecal coliform and e.coli. This correlation was further refined to look at dry weather and wet weather conditions separately. The data shows that during dry weather conditions a majority of the fecal coliform were not E. coli in samples with fecal coliform concentrations less than 350 organisms per 100 ml. In dry weather samples with fecal coliform greater

than 350 organisms/100 ml the majority of fecal coliform are E. coli. Under wet weather conditions almost 100% of the fecal coliform are E. coli. The correlation between fecal streptococcus and enterococcus is poor (scattered).

The following is a description of each sampling station (including the area upgradient which drains to each station) and summary of data collected over time at each location:

DATA ANALYSIS BY STATION

(Based on Data Collected During This Study)
2001 thru 2004

Mendham Pond Outfall, Mendham Twp.:

Area is mostly low density single family residential on septic systems. Sampling location is at the outfall of a bathing beach (pond) which is next to a public school. Large number of geese in this area (school and pond). Also heavily populated with deer. Data collected can be found in Brookside Beach Excel files. Data collected from beach inlet, bathing area and outlet indicate that sanitary quality most of the time complies with New Jersey standards (\leq 200 fecal coliform per 100 ml).

Whippany River behind Mendham Municipal Building:

The area that drains to this location is similar to the area that drains to the Mendham Pond (above). Area is mostly low density residential on septic systems. Geese and deer are a major problem. Historically this area did have problems with malfunctioning septic systems. However, over the years the Health Department did identify and correct the septic problems in this area. The Health Department (Health Department services provided by the Bernards Township Health Department) is unaware of any current malfunctioning septic systems in Mendham Township (see "Whippany Watershed Septic System Areas" report in **Appendix 3.**) Data collected from this sampling location indicates that under dry weather conditions water quality generally is acceptable for fecal coliform (dry weather geometric mean of 88.4 per 100 ml.). Under wet weather conditions the geometric mean for fecal coliform was 789.2 organisms per 100 ml. During wet weather conditions the fecal coliform/fecal streptococcus ratio indicates the sources to be animal.

Historical note for this site: In 1989 an investigation in this area revealed high fecal coliform counts (range 1,200 to 50,000 per 100 ml.) during wet weather conditions. During this investigation a farm (livestock) located upstream on West Main Street was observed discharging stormwater runoff with a fecal coliform concentration of 2,800,000 per 100 ml to the Whippany River. Sometime during the 1990's this farm was developed into a residential area. This source of fecal coliform no longer exists.

Harmony Brook at Main Street in Mendham Township:

The area that drains to this station is mostly forested and low density residential. The residential areas are on septic systems (see information mentioned above regarding septic systems in Mendham Township). Clyde Potts

Reservoir discharges to Harmony Brook upstream of this sampling location. This area has a very large deer population. Fecal coliform concentrations during dry weather sampling were acceptable (very low, 20 organisms per 100 ml). Fecal coliform concentrations during wet weather increased (geometric mean of 490 organisms per 100 ml) with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Dismal Brook at Main Street in Mendham Township:

The area that drains to this station is mostly forested and low density residential (similar to Harmony Brook mentioned above). This area is also mainly on septic systems. This area has a very large deer population. Fecal coliform concentration during dry weather conditions were acceptable (very low, 10 fecal coliform per 100 ml). Fecal coliform concentrations during wet weather increased (geometric mean of 363.3 fecal coliform per 100 ml.) with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Whippany River at Tingley Road, Mendham Township:

This station receives drainage from all areas mentioned above (see areas above for descriptions of drainage area). Fecal coliform concentrations during dry weather sampling were acceptable (geometric mean of 34.8 organisms per 100 ml.). Fecal coliform concentrations during wet weather were also acceptable (geometric mean of 142.5 organisms per 100 ml). During wet weather sampling the fecal coliform/fecal streptococcus ratios indicate animal sources.

Sunrise Lake Outlet, Mendham Township:

This station receives drainage from mostly forested and park land areas. Sunrise lake is used for recreational bathing. This drainage area is heavily populated with deer and geese. Only a few homes observed within this drainage area (approximately 12 homes, estate-like, located in Mendham Twp., on septic systems). Large accumulations of goose droppings observed around this lake. Samples were collected from streams entering the lake, the lake outfall, locations on the lake (which include epilimnion, hypolimnion and lake sediments). Sample results from all these locations can be found in the excel files (Sunrise Lake) which are included with this report. Dry and wet weather samples were acceptable for fecal coliform. During dry weather sampling the geometric mean for fecal coliform was 10 organisms per 100 ml. During wet weather sampling the geometric mean was 29.6 fecal coliform per 100 ml. During wet weather the fecal coliform/fecal streptococcus ratio indicates animal sources. There is additional chemical parameter data (dry weather conditions) included with this group of Excel files. Sediment data collected from this lake indicates that sediments may be a source (although not a significant source at this concentration) of fecal coliform (30 fecal coliform per gram) and fecal streptococcus (40 fecal streptococcus per gram). During heavy storm events the lake sediments may become resuspended into the water column and discharge through the lake outlet into the Whippany River.

Whippany River at Whitehead Road, Morris Township:

This station receives drainage from all areas mentioned above. This drainage area is mostly forested and low density residential (on septic systems). Both deer and geese appear to be a major problem in these areas. Septic systems do not appear to be a major problem or source. There is some agriculture observed in the area between Sunrise Lake and Whitehead Road. Part of Delbarton School drains to this area (Delbarton School discharges its sanitary waste to a

sanitary sewer). No dry weather data was collected for this station. During wet weather sampling (from 2 storm events) the geometric mean for fecal coliform was 1,271.6 per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Tributary at Whitehead Road, Morris Township:

This station receives drainage from mostly forested areas with some low density residential, wetlands and a small amount of agriculture. Homes in the area are on septic systems (see detailed listing in "Whippany Watershed Septic System Area" report in Appendix 3). This area is heavily populated by deer. During dry weather sampling the geometric mean for fecal coliform was 17.3 organisms per 100 ml. During wet weather sampling the geometric mean for fecal coliform was 1128.3 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Tributary at Washington Valley Road, Morris Township:

This station receives drainage from an area that is mostly forested/low density residential with a small amount of agriculture. The residential areas are on septic systems. This area has a very large deer population. During dry weather sampling the geometric mean for fecal coliform was 63.2 organisms per 100 ml. During wet weather sampling the geometric mean for fecal coliform was 106.7 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Gillespie Hill Tributary at Route 124, Morris Township:

This station receives drainage from mostly forested areas, some low density residential areas, and part of Delbarton School (which is on sanitary sewerage). The residential areas are mostly on sanitary sewerage with some homes on septic systems. Some agriculture is present. During dry weather sampling the geometric mean for fecal coliform was 22.4 organisms per 100 ml. During wet weather sampling the geometric mean for fecal coliform was 92.6 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Gaston Road Tributary (Jack's Brook), Morris Township:

This station receives drainage from mostly low to medium density residential areas with some forested areas. This area is mostly on sanitary sewerage with some areas on septic systems. This area contains a very large deer population. During dry weather sampling the geometric mean for fecal coliform was 24.5 organisms per 100 ml. During wet weather sampling the geometric mean for fecal coliform was 1,451.9 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Tributary B at Lake Rd./Ketch Rd., Morris Township:

This area receives drainage from mostly low density residential areas which are seweraged. There are some forested and recreational areas included. This area is heavily populated with deer. During dry weather sampling the geometric mean for fecal coliform was 70.7 organisms per 100 ml. During wet weather conditions the fecal coliform geometric mean was 2,336.7 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal source.

Tributary A at Lake Rd./Ketch Rd., Morris Township:

This area receives drainage from mostly low density residential areas (including a large nursing home - Morris View Nursing Home) which are sewerred. There are some forested areas and some agriculture. This area is heavily populated with deer. During dry weather sampling the fecal coliform concentration (based on one sampling event) was 20 organisms per 100 ml. During wet weather sampling the fecal coliform geometric mean was 1,643.2 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Whippany River at Lake Valley Road, Morris Township:

This area receives drainage from all of the areas mentioned above and some additional forested and low to medium density residential areas, schools and recreational fields. Some of the low density residential areas mentioned here are on septic systems (Washington Valley Road area). As per the Morris Township Health Department, the Washington Valley Road area has historically been a problem area for septic systems. The soil in this area is poor (usually encounter clay layers) for septic systems. The Health authority for Morris Township has stated that as of this time the Health Department is not aware of any malfunctioning septic systems in this area. The medium density residential areas mentioned here are sewerred (Sussex Ave./Lake Road areas). The areas mentioned here have heavy deer and geese populations. The Morris Township (Butterworth) sewage treatment plant is located immediately downstream of this sampling station. During dry weather conditions the fecal coliform geometric mean was 233.8 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating mixed (possibly animal and human) sources. During wet weather conditions the fecal coliform geometric mean was 993.3 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating mixed (possibly animal and human) sources. During wet weather sampling, when samples were collected during the storm event the fecal coliform/fecal streptococcus ratios indicated animal sources. When wet weather samples were collected one and two days after the storm event the fecal coliform/fecal streptococcus ratios indicated mixed (possibly animal and human) sources.

Watnong Brook at Lake Road, Morris Township:

This station receives drainage from both low and medium density residential areas, forested areas, agriculture, recreational fields, Greystone State Hospital, major roadways (Hanover Ave. and Route 10) and some commercial areas (including Powder Mill area and Shop Rite - goose problem areas). The residential areas are mostly sewerred (except for a small area in Parsippany (Puddingstone area) next to Greystone State Hospital which is on septic systems). Greystone State Hospital has a sanitary sewerage system with a wastewater treatment plant which discharges to Watnong Brook upstream of this sampling point. This area has a heavy deer and goose population. A County leaf composting facility is also located in this area. Mount Tabor Lake and Powder Mill Pond discharge to this Brook along with Jaqui and Watnong Ponds (both of which have a documented goose problem). During dry weather conditions the fecal coliform geometric mean was 228.4 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating mixed (possibly animal and human) sources. During wet weather conditions the fecal coliform geometric mean was 2,787.5 organisms with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Speedwell Lake Outlet at Speedwell Ave., Morristown:

This station receives drainage from all areas mentioned above along with an additional area which consists mostly of medium density residential and commercial land use (which are sewered). The area between Lake Valley Road and Speedwell Avenue, which drains to this station, has a significant deer and goose population. This area is also downstream of the Morris Township Butterworth sewage treatment plant outfall. During dry weather sampling the fecal coliform geometric mean was 107.0 organisms per 100 ml. During wet weather sampling the fecal coliform geometric mean was 1,014.8 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating mixed (possibly animal and human) sources. This was consistent with the prior station on the Whippany River (Whippany River at Lake Valley Road).

Whippany River at Center Street, Morristown:

This station receives drainage from all areas mentioned above and an additional area which consists mainly of medium to high density residential and commercial (more urban than suburban) land use which is sewered. Lake Pocahontas is also part of the additional area. This station is upstream of the Center Street storm drain outfall. During dry weather conditions the fecal coliform geometric mean was 42.0 organisms per 100 ml. During wet weather conditions the fecal coliform geometric mean was 845.8 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating mixed (possibly animal and human) sources. This again was consistent with the prior two stations on the Whippany River.

Burnham Pond Outfall, Morris Township:

This station receives drainage from mostly low and medium density residential and forested land uses. There is some agriculture in the drainage area. Burnham Pond is located in a public park (Burnham Park) which has a large goose population. Large number of goose droppings observed on the ground surrounding the pond. Most of the homes in this drainage area are sewered, there are some homes (Picatinny Road) which are on septic systems. There is a large deer population in this area as well. During dry weather sampling the fecal coliform geometric mean was 22.4 organisms per 100 ml. During wet weather conditions the fecal coliform geometric mean was 132.9 organisms per 100 ml. The Burnham Pond outfall discharges to a storm drain system in Morristown which eventually discharges to the Whippany River at Center Street (Center Street storm drain outfall).

Center Street Storm Drain Outfall to the Whippany River, Morristown:

This station receives drainage from the Burnham Pond outfall and is part of a storm water collection system for Morristown. The area in Morristown which drains (stormwater runoff) to this system is mostly a medium and high density urban area which is sewered. During dry weather conditions the fecal coliform geometric mean was 740.4 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating mixed (possibly animal and human) sources. During wet weather conditions the fecal coliform geometric mean was 1,828.3 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Whippany River at Hanover Avenue, Cedar Knolls:

This station receives drainage from all the above mentioned areas and a drainage area between Center Street (Morristown) and Hanover Avenue (Morris Township/Cedar Knolls) which consists mostly of medium and high density

residential and commercial land use. This area includes Morristown Memorial Hospital, Morristown Beard High School and recreational fields (goose problem), Frelinghuysen Arboretum and a large commercial area with some industry along Ridgedale Avenue (Morristown and Morris Township). This area also receives drainage from a portion of Route 287. This area has a large goose population and deer population. This area is sewerred. During dry weather conditions the fecal coliform geometric mean was 156.5 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources. During wet weather conditions one sample was collected at this station which had a fecal coliform concentration of 320 organisms per 100 ml and a fecal coliform/fecal streptococcus ratio indicating animal sources.

Horsehill Road Tributary, Cedar Knolls:

This station receives drainage from mostly a forested, industrial/commercial land use area with some medium density residential areas. This area is sewerred and has a large deer and goose population. The area immediately around this sampling location is heavily populated with geese and large accumulations of goose droppings have been observed on the ground. A separate study was conducted in this area due to high fecal coliform counts. A human source had been identified (overflowing, clogged sewer line) and had been resolved. The sanitary sewer lines in this area were inspected for leakage (no leakage found). A report was generated regarding these activities (report can be found in **Appendix 3**). There is an industrial point source discharge (NJPDES permit issues to Airtron for treated effluent from a metal plating operation) upstream of this sampling point. During dry weather conditions the fecal coliform geometric mean was 418.7 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating human sources. This data indicates that a human source may still exist. A ground surface survey of this area could not confirm a human source. It may be possible that the sanitary sewerage collection system in this area may be leaking small amounts of sewage into this tributary. This potential source was investigated by the Hanover Sewerage Authority who stated that based on their investigation the system is not leaking. Further investigation in this area is needed to confirm the source of elevated fecal coliform. During wet weather conditions the fecal coliform geometric mean was 2,994.7 with a fecal coliform/fecal streptococcus ratio indicating animal sources.

East Frederick Road Tributary, Cedar Knolls:

This sampling location receives drainage from the Horsehill Road Tributary (mentioned above - Horsehill Road Tributary and East Frederick Road Tributary are the same tributary). The drainage area between the Horsehill Road and East Frederick Road stations consists mainly of forested industrial/commercial land use with some medium density residential areas. This area is sewerred. During dry weather conditions the fecal coliform geometric mean was 173.2 organisms per 100 ml. During wet weather one sample was collected which had a fecal coliform concentration of 220 organisms per 100 ml.

Boulevard Road Tributary, Cedar Knolls:

The area that drains to this sampling location consists mainly of medium density residential land use with some forested areas. This area is sewerred and has a large deer population. This tributary is the outfall of the storm drain collection system for this area. Residents have reported seeing animals (mainly raccoons and cats) entering and exiting this storm drain system. During dry

weather the fecal coliform geometric mean was 145.6 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources. During wet weather the fecal coliform geometric mean was 34,979.3 organisms with a fecal coliform/fecal streptococcus ratio indicating animal sources. During extended dry weather periods there is no flow in this tributary.

Whippany River at South Jefferson Road, Whippany:

The area that drains to this sampling location includes all the areas mentioned above and a drainage area (between Hanover Avenue and South Jefferson Road) which consists mostly of medium density residential with some forested and industrial/commercial land use areas. This area is sewerred. This station is downstream of the Morristown Sewage Treatment Plant outfall. This station also received drainage from a NJ Department of Transportation maintenance yard and a portion of Route 287. This area has a large deer and goose population. During dry weather the fecal coliform geometric mean was 133.0 organisms per 100 ml. During wet weather the fecal coliform geometric mean was 726.5 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating mixed sources (possible animal and human sources).

Whippany River at Parsippany Road, Whippany:

The area that drains to this sampling location includes all of the areas mentioned above and a drainage area between South Jefferson Road and Parsippany Road which consists of medium density residential, commercial and industrial land uses. Some forested area exists along with some recreational fields (Central Park and the Jewish Community Center). This area is sewerred and has a large goose population. Deer activity in this area appears to be sporadic, large number of raccoons and skunks. During dry weather the fecal coliform geometric mean was 64.8 organisms per 100 ml. During wet weather the fecal coliform geometric mean was 582.7 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Malapardis (aka Stoney Brook) Brook at Parsippany Road, Whippany:

The area that drains to this sampling location consists mostly of commercial (three large hotel complexes and large office parks) and forested land use with some moderate density residential areas. This area receives drainage from a portion of Route 287 and Route 10. Hanover Township's municipal complex, recreation building and public works department are located within this drainage area. This area includes Stoney Brook Pond (Hanover Township) and Community Park Pond (Morris Plains Borough) which have heavy goose populations. This area is sewerred and has a heavy deer population as well. During dry weather the fecal coliform geometric mean was 96.6 organisms per 100 ml. During wet weather conditions the fecal coliform geometric mean was 425.1 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Pinch Brook Tributary at Ridgedale Avenue, Florham Park:

The area that drains to this sampling location consists of the Pinch Brook Golf Course (which has a very large goose population), medium density residential and commercial areas. This area is sewerred and has a large goose population. During dry weather the fecal coliform geometric mean was 20.0 organisms per 100 ml. During wet weather the fecal coliform geometric mean was 1,944.2 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Tributary at Elm Street and Columbia Turnpike (aka Hassock Brook), Florham Park:

The area that drains to this sampling location consists of forested areas, deciduous wooded wetlands and medium density residential areas. Most of this area is sewerred. There is a small residential area (Elm Street Area) that uses septic systems. There is a large recreational complex located in this area. Large goose and deer populations exist in this area. During dry weather the fecal coliform concentration (based on one sample) was 180 organisms per 100 ml. During wet weather the fecal coliform geometric mean was 3,000.0 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Black Brook at Columbia Turnpike, Florham Park:

The area that drains to this sampling location consists mainly of deciduous scrub and wooded wetlands, herbaceous wetlands, large corporate and commercial (office) development and some forested areas. This area also contains a significant amount of moderate density residential areas along with three college campuses (St. Elizabeth, Fairleigh Dickinson and Drew University), two high Schools (Madison High School and Bayley Ellard High School) and a number of recreational fields. This area also receives drainage from Route 24 and a portion of a golf course (located in Morris Township). This area has a very large goose and deer populations. This area is sewerred. During dry weather the fecal coliform geometric mean was 64.6 organisms per 100 ml. During wet weather the fecal coliform concentration (based on one sampling event) was 5,100 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Park Avenue Tributary, Whippany:

The area that drains to this sampling location consists mainly of medium density residential areas with some forested areas. This area is sewerred and contains a large deer population. During dry weather the fecal coliform geometric mean was 114.9 organisms per 100 ml. During wet weather the fecal coliform concentration (based on one sample event) was 15,000 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Whippany River at Melanie Lane, East Hanover:

The area that drains to this sampling location included all of the areas mentioned above and includes an area between the Parsippany Road and Melanie Lane stations which consists mainly of medium density residential areas, wetland and forested areas (Black Meadows and Morristown Airport), a golf course (Anchor Golfland), commercial and some industrial (including Lucent Technologies) areas. This area is sewerred and has a large deer and goose population. During dry weather the fecal coliform geometric mean was 149.4 organisms per 100 ml. During wet weather the fecal coliform geometric mean was 706.7 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Bee Meadow Pond Outfall, Whippany:

The area that drains to this sampling location consists mostly of medium density residential and forested land uses. This area includes an automobile salvage yard and trucking yard. This area is sewerred and has a large deer and goose population. A chicken farm is located immediately adjacent to the Bee Meadow Ponds. The ponds have a very dense goose and duck population with large

accumulations of feces on the ground around the ponds. During dry weather the fecal coliform geometric mean was 74.2 organisms per 100 ml. During wet weather the fecal coliform geometric mean was 704.7 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating possible animal sources.

West Brook at South Beverwyck Road, Parsippany:

The area that drains to this sampling location consists of the Bee Meadow Pond outfall (mentioned above), Old Troy Park (which includes a pond), medium density residential areas, forested areas and some wetland areas. This area is sewered and has a large deer population. At this sampling location there are two tributaries (labeled left trib and right trib looking upstream). The left trib appears to drain the property to the left. The dry weather fecal coliform geometric mean was 44.7 organisms per 100 ml for the left trib. The wet weather fecal coliform geometric mean was 359.1 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources. The right trib is West Brook. The dry weather fecal coliform geometric mean for West Brook was 215.4 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources. The wet weather fecal coliform geometric mean for West Brook was 1,571.9 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Troy Brook at Troy Road, Parsippany:

The area that drains to this sampling location consists of a majority of the north-west section of the watershed. This area includes drainage from the Mountain Lakes in Mountain Lakes Borough, Lake Parsippany, Intervale Lake and the Rainbow Lakes in Parsippany. This area consists largely of medium density residential with a significant amount of commercial/industrial areas along Route 46, Route 287 and Parsippany Road in Parsippany. Some forested areas also exist. This area receives a significant amount of drainage from Route 46, Route 287 and Route 80. This area is sewered and contains a large goose and deer population. The dry weather fecal coliform geometric mean was 103.8 organisms per 100 ml. The wet weather fecal coliform geometric mean was 876.0 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Whippany River at Edwards Road, Parsippany:

The area that drains to this sampling location consists of all the above mentioned areas and an area between the Melanie Lane and Edwards Road stations that consists mostly of wetlands/meadows (Troy Meadows) with medium density residential areas (East Hanover) and some commercial/industrial areas (East Hanover/Hanover Townships). The Hanover Township Wastewater Treatment Plant is located in this area and discharges to the Whippany River upstream of Troy Road in East Hanover. This area also contains a portion of Sharkey's Landfill, the Morris County Solid Waste Transfer Station and a portion of the Parsippany Troy Hills Wastewater Treatment Plant. The effluent of the Parsippany Troy Hills Wastewater Treatment Plant discharges to the Whippany River downstream of this location. This area has a large deer and goose population. This area is sewered. This is the last station on the Whippany River and is approximately 0.3 miles upstream of the confluence with the Rockaway River. The dry weather fecal coliform geometric mean was 70.7 organisms per 100 ml. The wet weather fecal coliform geometric mean was 876.1 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.

Note: Pets are present in all residential areas mentioned above. Pets should be included as a significant source of fecal contamination in all residential areas (pet waste which is not picked up could be washed into storm drain systems and surface waters with stormwater runoff).

9) Conclusions and Recommendations

During this study a extensive sanitary survey of the Whippany River Watershed was conducted which included an extensive sampling of surface waters (under both dry and wet weather conditions), suspected sources, sediments and fecal matter; field surveys; GIS mapping (which included digital orthophotography and topographic map overlays) and analysis; and an evaluation of historic water quality data. The following conclusions are made based on the findings from this investigation:

a) **HISTORIC ANALYSIS OF DRY WEATHER TRENDS**

Dry weather data collected over time was analyzed in an effort to determine fecal coliform trends within the Whippany River over an 18 year period. Fecal coliform data from five locations along the Whippany River were used in the analysis. These locations include the stations at Lake Valley Road (Morris Township), Speedwell Lake Outfall at Speedwell Ave. (Morristown), South Jefferson Road Bridge (Hanover Township), Melanie lane Bridge (East Hanover), and Edwards Road (Parsippany). Fecal coliform averages were calculated over the periods of 1985 (where data exist), 1994-1995 (NJDEP data) and 2001-2003. The following table shows the results from this analysis:

Geometric Mean Fecal Coliform Concentrations (# orgs/100ml)			
<u>Station Location</u>	<u>1985</u>	<u>1994-1995</u>	<u>2001-2003</u>
Lake Valley Road		246.5	233.8
Speedwell Lake Outfall	200.0	646.9	107.0
S. Jefferson Road	531.3	286.9	133.0
Melanie Lane		279.1	149.4
Edwards Road		416.8	70.7
DRY WEATHER			
RIVER MEAN FOR PERIOD		375.2	138.8

Note: River Mean is based on data from the above five mentioned stations.

The 1985 data was very limited (data existed for only 2 of the 5 above mentioned stations) and should only be used to compare data at the Speedwell Lake and S. Jefferson Road stations. Fecal coliform concentrations decreased from a 1994-1995 River mean of 375.2 organisms per 100 ml to a 2001-2003 River mean of 138.8 organisms per 100 ml. This represents a 63.0% decrease in fecal coliform from 1994-1995 to 2001-2003 during dry weather conditions.

This study shows that during dry weather conditions that most of the Whippany River does comply with the current NJDEP standards for fecal coliform. NJDEP surface water quality standard for the Whippany River (as per NJAC 7:9B1.14) is "Fecal coliform levels shall not exceed a

geometric average of 200/100 ml nor should more than 10 percent of the total samples taken during any 30-day period exceed 400/100 ml."

b) **HISTORIC ANALYSIS OF WET WEATHER TRENDS**

Wet weather data was collected in an effort to evaluate fecal coliform trends over time for the Whippany River. Wet weather samples were collected during the periods from 1996-1998 and 2001-2003. The 1996-1998 data was collected by Killam Associates through a grant from the NJDEP. It is important to note that the 1996-1998 data consisted of multiple grab samples collected throughout 3 storms during that period. The data provides a good representation of the variability which occurred during each storm. The 2001-2003 data consist of one grab sample collected during each storm event (six storm events were sampled) which does not provide a good representation of the variability which can occur during each storm (concentration could vary significantly depending on when the sample was collected during the storm). For this reason the comparison over time is made with the understanding that a significant amount of error does exist in the method used. This is based on the limited number of samples collected during the 2001-2003 storm events.

The Edwards Road station (last station on the Whippany River located approximately 1/4 mile upstream of the confluence with the Rockaway River) is the only Whippany River station in this study where both historical data and current wet weather data sets exist together. Therefore this is the only station where an evaluation of the historical trends could be made. The following table shows the results from this analysis:

<u>Station Location</u>	<u>Geometric Mean Fecal Coliform Concentrations (# orgs/100ml)</u> <u>1996-1998</u>	<u>2001-2003</u>
Edwards Road (Parsippany)	1326.0	876.1

Important note: 1996-1998 data consists of multiple grab samples collected throughout each storm event. This provides for a good accounting of the variability occurring throughout each storm event. 2001-2003 data consists of one grab sample collected during each storm event. This does not provide for a good accounting of the variability and introduces error into this analysis.

From an analysis of the data collected during this study, during wet weather conditions the majority of the Whippany Watershed does not comply with the above mentioned NJDEP criteria for fecal coliform.

c) **SOURCES OF FECAL CONTAMINATION WITHIN THE WHIPPANY WATERSHED**

From the data collect during this study the following statements are made regarding sources of fecal contamination:

- 1) Septic systems, which are located primarily in the upper portion (Mendham Township, Morris Township) of the Whippany Watershed, do not appear to be a significant source of fecal contamination during the time of this study. Local health departments appear to be very effective in identifying and

remediating malfunctioning septic systems in a timely manner within the study area.

- 2) Sanitary sewerage systems (which are separate from the storm drain collection systems) which serve the remaining watershed appear to be functioning properly. Systems (both collection and treatment) do not appear to be over capacity. There are five publicly owned wastewater treatment plants which discharge treated effluent to the Whippany River (Greystone State Hospital which discharges to Watnong Brook, Morris Township Butterworth Plant which discharges below Lake Valley Road, Morristown which discharges below Hanover Avenue, Hanover which discharges above Troy Road in East Hanover, and Parsippany Troy Hills which discharges below Edwards Road before the confluence with the Rockaway River). When sewage back-ups do occur the sewerage authorities and/or health authorities do respond quickly to remediate the condition. Back-ups do not appear to be a common occurrence within the watershed.
- 3) During this study two sanitary sewage discharges to the Whippany River were identified. These discharges were located at Saddle Road in Hanover Township and near Center Street in Morristown. The Saddle Road discharge was from a building sanitary sewer line which clogged and backed up onto the surface of the ground and into the storm drain system. This source was immediately remediated once it was detected. The Center Street (Morristown) discharge appears to be intermittent and still existing. This discharge has been brought to the attention of the Morristown Health Department for their follow-up and action. Detailed information on both discharges can be found in the main body of this report.
- 4) Data from this study indicates that there may be a human source of fecal contamination upstream of the Lake Valley Road (Morris Township) site. This area receives drainage from all of the stations listed above this point (please refer to "Data Analysis by Station" in the above discussion section) and some additional forested and low to medium density residential areas, schools and recreational fields. Some of the low density residential areas mentioned here are on septic systems (Washington Valley Road area). As per the Morris Township Health Department, the Washington Valley Road area has historically been a problem area for septic systems. The soil in this area is poor (usually encounter clay layers) for septic systems. The Health authority for Morris Township has stated that as of this time the Health Department is not aware of any malfunctioning septic systems in this area. The medium density residential areas mentioned here are sewer served (Sussex Ave./Lake Road areas). The areas mentioned here have heavy deer and geese populations. The Morris Township (Butterworth) sewage treatment plant is located immediately downstream of this sampling station. During dry weather conditions the fecal coliform geometric mean was 233.8 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating mixed (possibly animal and human) sources. During wet weather conditions the fecal coliform geometric mean was 993.3 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating mixed (possibly animal and human) sources. During wet weather sampling, when samples were

collected during the storm event, the fecal coliform/fecal streptococcus ratios indicated animal sources. When wet weather samples were collected one and two days after the storm event the fecal coliform/fecal streptococcus ratios indicated mixed (possibly animal and human) sources.

- 5) Data from this study indicates that there may be a possible human source of feces upstream of the Watnong Brook at Lake Road (Morris Township) sampling location. This station receives drainage from both low and medium density residential areas, forested areas, agriculture, recreational fields, Greystone State Hospital, major roadways (Hanover Ave. and Route 10) and some commercial areas (including Powder Mill area and Shop Rite - goose problem areas). The residential areas are mostly sewered (except for a small area in Parsippany (Puddingstone area) next to Greystone State Hospital which is on septic systems). Greystone State Hospital has a sanitary sewerage system with a wastewater treatment plant which discharges to Watnong Brook upstream of this sampling point. This area has a heavy deer and goose population. A County leaf composting facility is also located in this area. Mount Tabor Lake and Powder Mill Pond discharge to this Brook along with Jaqui and Watnong Ponds (both of which have a documented goose problem). During dry weather conditions the fecal coliform geometric mean was 228.4 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating mixed (possibly animal and human) sources. During wet weather conditions the fecal coliform geometric mean was 2,787.5 organisms with a fecal coliform/fecal streptococcus ratio indicating animal sources.
- 6) Data collected from the Center Street storm sewer outfall (Morristown) indicate that there may be both animal and human fecal sources within the storm drain collection system upgradient of the outfall. Animal sources may be from rodent and other terrestrial wildlife living within the storm drain collection system. This station receives drainage from the Burnham Pond outfall and is part of a storm water collection system for Morristown. The area in Morristown which drains (stormwater runoff) to this system is mostly a medium and high density urban area which is sewered. During dry weather conditions the fecal coliform geometric mean was 740.4 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating mixed (possibly animal and human) sources. During wet weather conditions the fecal coliform geometric mean was 1,828.3 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources.
- 7) Pet waste may be a fecal source in the more densely developed residential areas (medium to high density area). During dry weather conditions most of the stations located within these areas met the 200 fecal coliform/100 ml criteria. However, during wet weather conditions the fecal coliform levels recorded at these stations greatly exceeded the surface water criteria with concentrations which ranged from 727 to 34,979 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources. The low density residential areas during wet weather conditions had fecal coliform concentrations which were much lower and ranged from 143 to 1,271.6 organisms per 100 ml with a fecal coliform/fecal streptococcus ratio indicating animal sources. It makes sense to say that pet density is directly related to

residential density. If residents are not picking up after their pets then pet waste in both medium and high density residential areas (medium and high density residential areas would also have more impervious coverage and more surface runoff than low density area) could be a significant source of fecal contamination to the Whippany River during wet weather conditions.

- 8) Throughout the Whippany Watershed there are very dense goose and deer populations. Goose populations are greatest in areas around ponds and in areas which are open with mowed lawns (athletic fields, corporate lawns, parks, school yards, residential areas with large lawns, stormwater detention systems consisting of mowed lawn vegetation). Deer populations are greatest in the more wooded areas (forested areas, meadow areas, low and medium density residential areas). Droppings from these animals are deposited onto the ground and may wash into surface waters with runoff. Goose droppings in many of the above mentioned open areas are so dense that it becomes difficult to walk without soiling shoes.
- 9) Animals living in storm drain collection systems appear to be a source of fecal contamination in stormwater runoff. This was first observed at the Boulevard Road site in Hanover Township. Groundwater baseflow moving through the storm drain system in this area was picking up fecal contamination (under dry weather conditions) from what appeared to be animal sources. The dry weather geometric mean for fecal coliform at this sampling location (which is the outfall for an underground stormwater collection system in a medium density residential area which was sewered) was 145.6 organisms per 100 ml and the fecal streptococcus concentration was 569.6 organisms per 100 ml. The dry weather FC/FS ratio was 0.3 which strongly indicates animal source. A survey of the drainage area above this sampling point did not reveal any human sources. People living in this area did state that on numerous occasions they did observe raccoons and cats entering and leaving the storm sewer catch basins. It appears that the raccoons are living in this system (and may be depositing feces into this system). There is flow in this system most of the time which appears to be groundwater baseflow. The only time this system is dry (no flow at the sampling location) is when there is an extended dry period (no rain for at least a two week period) in the region. This is seen more often in the late summer/early fall months. This observation is probably a common occurrence in most of the stormdrain collection systems throughout the watershed. In systems where there is no flow during dry weather periods, fecal matter from these animals could accumulate and then be flushed out with stormwater runoff during a storm event.
- 10) Sediments in ponds which have large goose populations could act as a source of fecal matter and fecal coliform. If the grounds surrounding a pond have heavy accumulations of fecal matter the fecal matter could wash into the pond with runoff

during a storm event. Ponds tend to act as settling basins for sediments and suspended solids. Fecal matter entering the pond could settle to the bottom and become part of the pond sediments. Fecal matter in these sediments will decompose over time. However, fecal coliform and fecal streptococcus may survive for an extended period in these sediments (Van Orden, 1990). *Escherichia coli* (a fecal coliform organism) has been found to multiply in sediments (Solo-Gabriele, et al 2000) as well. During heavy rains the sediments in a pond could be scoured off the bottom (as flow through the pond increases) and re-suspended into the water column. These sediments would then be discharged with the pond outfall. This could include indicator organisms which may be present in the pond sediments. Sediment samples collected from the bottom of Sunrise Lake (Morris Township) were tested for fecal coliform and fecal streptococcus. 30 fecal coliform per gram and 40 fecal streptococcus per gram were found. Sampling of the water column above these sediments (under dry weather conditions at Sunrise lake) revealed that <10 fecal coliform/100 ml and 10 fecal streptococcus per 100 ml were present in the epilimnion. 30 fecal coliform/100 ml and 20 fecal streptococcus/100 ml were found in the hypolimnion immediately above the sediments. This data suggests that pond sediments may be acting as a minor source of the fecal indicators found in the ponds outfall during a storm event. More studies are needed in this area to better understand the role pond (or lake) sediments play as a source of fecal indicators.

Note: listing of all animal fecal sources (by location) identified during this study may be found in Appendix 3.

d) SEASONAL VARIABILITY OF FECAL COLIFORM CONCENTRATIONS

The data generated during this study clearly shows that, during dry weather periods, seasonal variability exist with respect to fecal coliform and fecal streptococcus in surface waters. The fecal coliform and fecal streptococcus concentrations in surface waters throughout the watershed were much lower in the colder winter month when compared to the warmer summer months. Freezing temperature appears to have a negative effect on the fecal indicators. This was observed when comparing data from fecal samples collected during this study. Frozen fresh goose droppings contained significantly less fecal coliform and fecal streptococcus than fresh droppings collected during the summer months (this data is presented in the discussion section of this report). Dry fecal droppings also contained significantly less fecal indicators than moist droppings. The negative effect that freezing appears to have on the indicator organisms in combination with a decrease in animal activity during winter months may provide some explanation for the decreases observed (of fecal bacteria) in the surface water during colder weather. Aftergrowth of the indicator organisms in the environment is also a function of temperature. Warmer water temperatures could increase the growth rate of fecal

indicators in the surface water environment (aftergrowth) thereby increasing their concentration. It has been well documented that some of the fecal indicator species have the ability to multiply naturally in a water environment. Therefore, the seasonal variability appears to be due to the effects of freezing temperatures (increasing the death rate) on the indicator bacteria, the effect warmer temperatures have on aftergrowth and a decrease of animal activity during the cold winter months. More research is needed to verify this hypothesis.

Final Note

On February 2, 2004, the New Jersey Department of Environmental Protection adopted the "Stormwater Management" regulations. These new regulations will require municipalities to adopt and enforce pet waste, improper waste disposal, wildlife feeding and illicit connection ordinances. The new regulations also require municipalities to develop illicit connection elimination and stormwater facility maintenance programs. These requirements can be found in NJAC 7:8.1 et seq. Since these regulations address many of the sources mentioned above, the sanitary quality of the Whippany River is expected to improve with their implementation.

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