

Water Quality Impacts from Dairies in Washington State: A Literature Review

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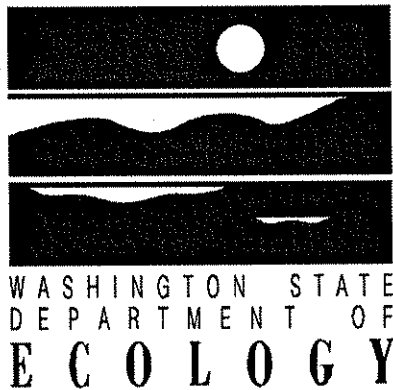
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by
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Olympia, Washington 98504-7600

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Abstract

A literature review was conducted of surface water quality studies related to dairy waste practices. The review examined 48 documents statewide, and summarized each document's conclusions regarding water quality degradation or beneficial use impairment due to dairy waste. The most common water quality impacts were higher fecal coliform levels and lower dissolved oxygen levels. The most common beneficial use impairment was fish habitat degradation. The study areas corresponding to each document are shown on maps together with dairy locations. The areas where dairies were most directly related to water quality problems were Johnson, Dakota, Kamm, Bertrand, Fishtrap, and Tenmile creeks in Whatcom County; Samish River in Skagit County; and Newaukum Creek in King County. Areas lacking sufficient information included the South Fork and Lower Nooksack River, Lummi River, and Saar Creek in Whatcom County, Whidbey Island, the Enumclaw plateau in Pierce County (draining to the Puyallup River), the Cowlitz River, and areas of Grant and Franklin counties.

Introduction

Background

The Washington State Department of Ecology (Ecology) has known for some time that improper dairy waste management can have a detrimental effect on the state's waters in certain areas. However, a comprehensive summary of water quality effects from dairies throughout the state had not been compiled. The purpose of this project was to conduct a literature review of surface water quality studies that examined impacts from dairy waste and to summarize the results in an easy-to-understand format. In addition, the review was to identify problem areas to help prioritize Ecology's Water Quality Program actions and to identify areas with significant data gaps to help prioritize monitoring efforts.

Assessment of Water Quality Impacts

Information on water quality degradation from dairies was summarized in terms of two measures: beneficial use impairment and water quality degradation. Most documents did not specifically assess beneficial use impairment. However, Washington State has established water quality criteria to protect certain beneficial uses of the state's waters. These uses are summarized in the following table for each classification category (Class AA, A, B, C, and Lake Class). Therefore, if a water quality criterion was shown to be violated, it can be assumed that the corresponding beneficial uses are likely to be threatened. Water quality criteria are listed in Appendix A for the most commonly mentioned water quality parameters.

This literature review did not attempt to assess the relative effect of dairies compared to other nonpoint sources of pollution. In many cases, other pollution sources are mentioned as also contributing to water quality degradation.

The water quality studies summarized in this report represent conditions at the time the studies were conducted. The number, size, location of dairy farms, and specific waste management practices occurring at individual farms change over time throughout the state. Therefore, this report represents a "snapshot in time" of dairy water quality impacts.

This report was also not intended to address the effects of improved dairy waste management practices. The information summarized in this document represents dairies with a wide range of waste management handling techniques, from essentially no improvements to those with extensive systems for minimizing pollution. Many of the studies cited were intended in part to provide baseline information to compare to future, hopefully improved, water quality measurements after the implementation of better waste management practices.

Beneficial uses protected by Washington State water quality standards (Ch. 173-201A WAC).

| | Lake Class | Class AA Extraordinary | Class A Excellent | Class B Good | Class C Fair |
|---|--|---|--|--|---|
| Water quality of this class shall: | meet or exceed the requirements for all or substantially all uses. | markedly and uniformly exceed the requirements for all or substantially all uses. | meet or exceed the requirements for all or substantially all uses. | meet or exceed the requirements for most uses. | meet or exceed the requirements of selected and essential uses. |
| <u>Characteristic Uses:</u> | | | | | |
| Water supply: | | | | | |
| Domestic | X | X | X | X | |
| Industrial | X | X | X | X | |
| Agricultural | X | X | X | X | X |
| Stock watering | X | X | X | X | |
| Fish and shellfish: | | | | | |
| Salmonid spawning | X | X | X | X | |
| Salmonid rearing and harvesting | X | X | X | X | |
| Other fish rearing, harvesting, and spawning | X | X | X | X | |
| Salmonid and other fish migration | X | X | X | X | X |
| Clam, oyster, and mussel harvesting | X | X | X | X | |
| Clam, oyster, and mussel rearing and spawning | X | X | X | X | |
| Crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing, spawning, and harvesting | X | X | X | X | |
| Wildlife habitat | X | X | X | X | |
| Recreation: | | | | | |
| Primary contact recreation | X | X | X | | |
| Secondary contact recreation, sport fishing, boating, and aesthetic enjoyment | X | X | X | X | X |
| Commerce and navigation | X | X | X | X | X |

Criteria for Document Inclusion

The following criteria were used for including documents in the literature review:

- The document contained information on water quality that could in some way be related to dairies.
- The water quality information was less than ten years old. Exceptions to this rule were made for reports that were considered to be high quality and/or no more recent information was available.
- The information was in the form of a published document. Data tables and computer database files, for example, were not included. The document also needed to contain analyses and conclusions, not simply a presentation of the water quality data.

This report focused on surface water quality only. Ground water is also potentially affected by poor dairy waste practices, especially from excessive land application of manure to fields. However, relatively few studies were found that related ground water quality to dairies. Including the few studies available could give a misleading impression that dairies are not contributing to ground water quality problems. Therefore this report summarized the more geographically extensive surface water studies.

Format of Document Summaries

The document summaries are presented in the following format:

- **Reference:** the complete bibliographic reference.
- **Summary:** a brief summary of the document's conclusions regarding water quality impacts from dairy waste.
- **Objectives:** study objectives.
- **Background:** background information to help put the information in context.
- **Land Use:** the extent of dairy farming in the study area. This section often includes an estimate of the number of dairies in the study area and the number of dairy cows, as given in the report. Because the number of dairies and cows in a study area is constantly changing, these numbers may not reflect current conditions.
- **Impaired Beneficial Uses:** any information on beneficial use impairment.
- **Water Quality:** water quality information and violations of water quality criteria.
- **Monitoring:** water quality monitoring work conducted as part of the study.

For reference, a list of all documents and their corresponding Water Resource Inventory Area and Waterbody Identification Numbers are presented in Appendix B. The sources used to obtain the documents are listed in Appendix C.

Study Areas

Figures 1 through 6 show the study areas corresponding to documents that found dairies to be degrading water quality. Figure 1 shows all study areas statewide, and Figures 2 through 6 show the same information in more detail, including dairy locations. When one study area is contained within another, the sub-area is given a letter, such as 1a. The study area for document 1, for example, includes the areas labeled 1, 1a, 1b, etc. Dairy farm locations were obtained from the Washington State Department of Agriculture (a computer software program was used to translate farm addresses to map coordinates).

Findings of Water Quality Impacts from Dairies

The most common water quality problem mentioned in the documents was an increase in fecal coliform levels, followed closely by a decrease in dissolved oxygen levels. Other parameters often mentioned as being affected by dairy wastes include temperature, turbidity, and ammonia.

Water quality impacts were found most commonly in tributaries of major river systems, as opposed to the mainstem river reaches. However, there were many exceptions to this pattern, including the mainstem Snoqualmie River in selected reaches, the Willapa River, and the Yakima River downstream of the Granger Drain.

The most common beneficial use impairment cited was fish habitat degradation, especially in tributaries used for spawning and rearing. Another common concern was shellfish harvesting impacts. Other impaired beneficial uses mentioned were drinking water and contact recreation.

For the majority of studies, it was difficult to isolate the dairy-caused water quality impacts from other nonpoint pollution sources. The reports usually did not focus specifically on dairy impacts as an objective of the study. For example, the studies' sampling sites usually did not bracket solely dairy farming operations. Exceptions were in areas where the land use was nearly exclusively dairy farming.

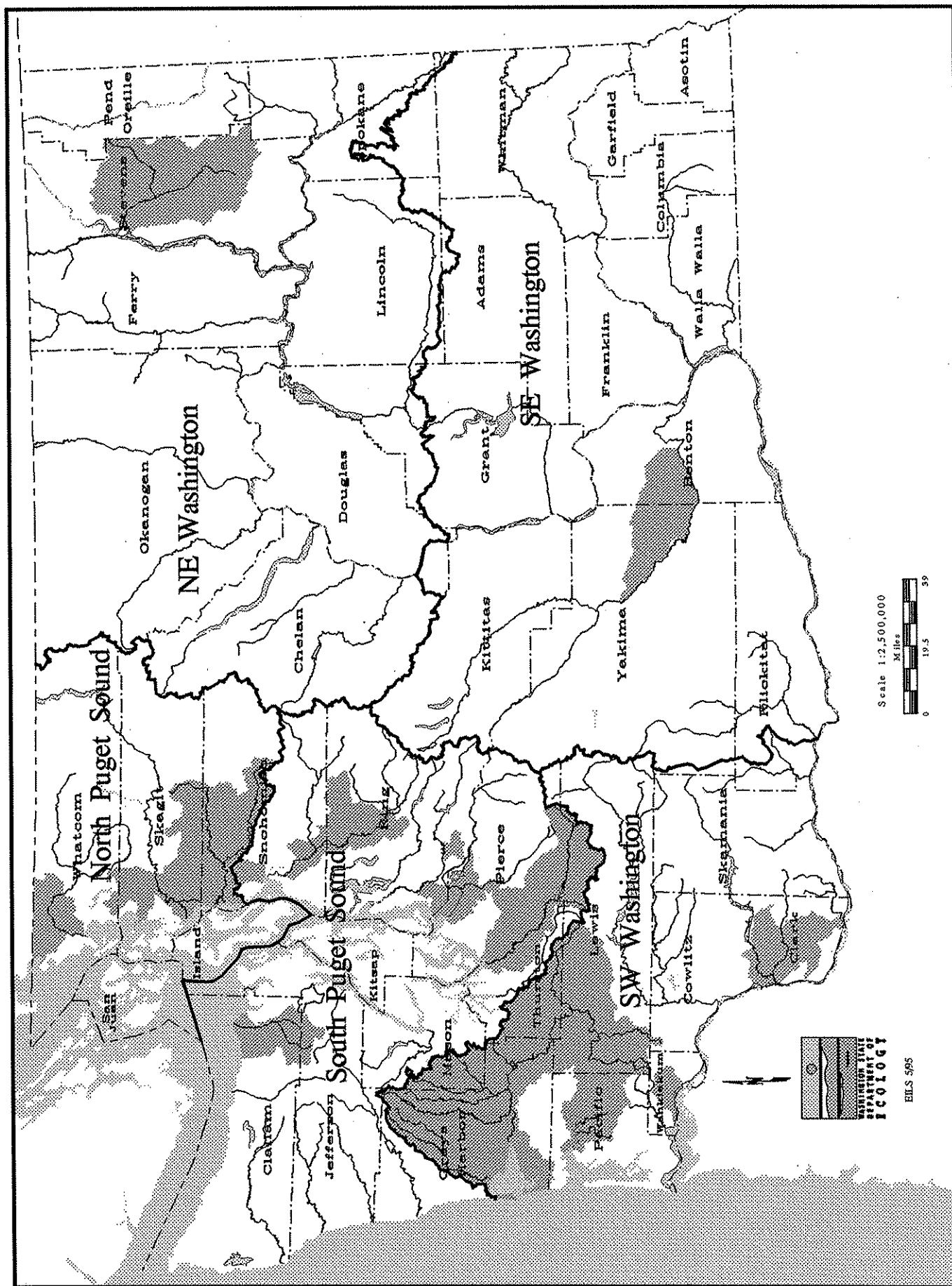


Figure 1. Study areas of documents that found dairy waste to be degrading water quality - statewide map.

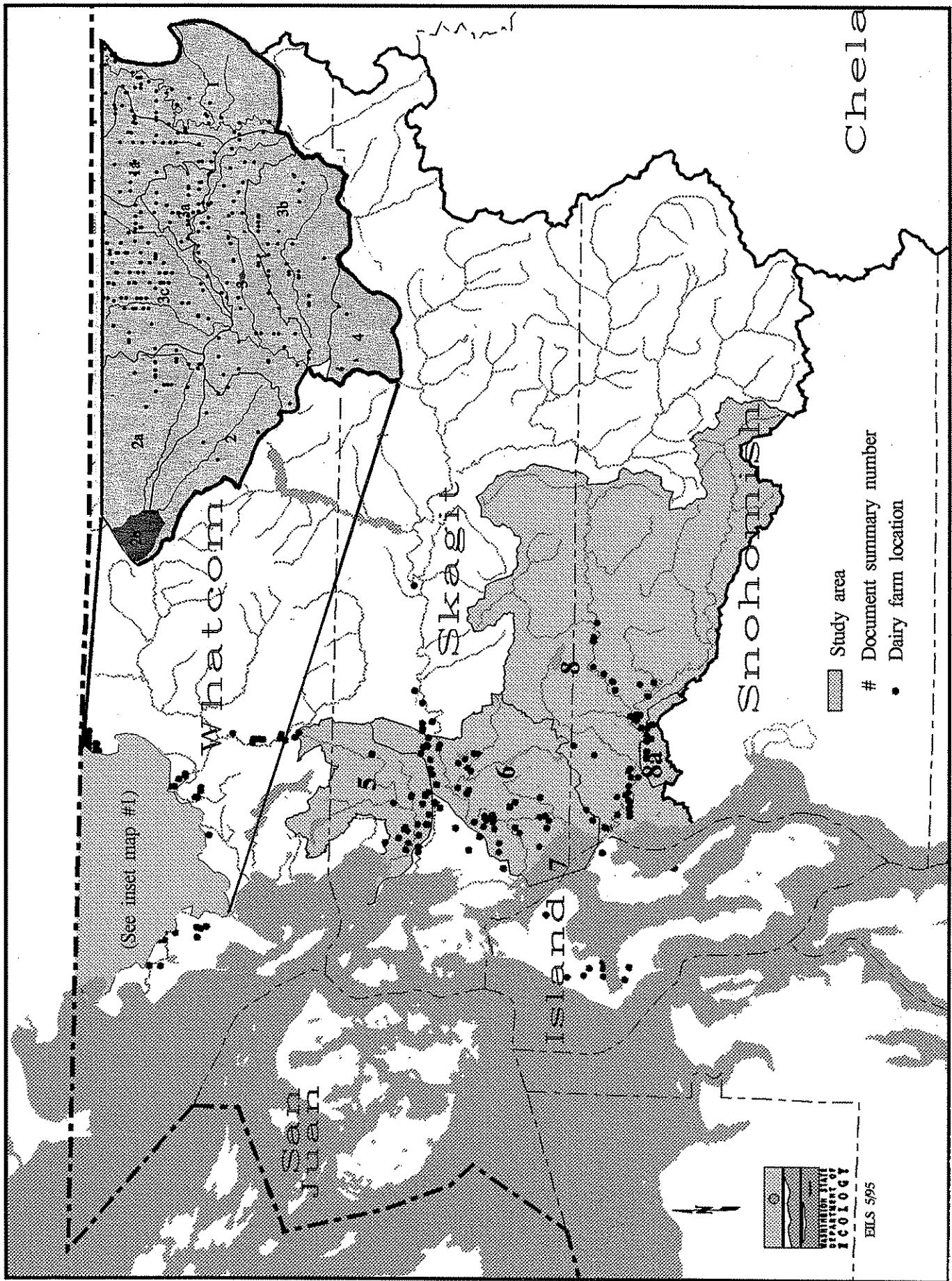


Figure 2. Study areas of documents that found dairy waste to be degrading water quality - north Puget Sound.

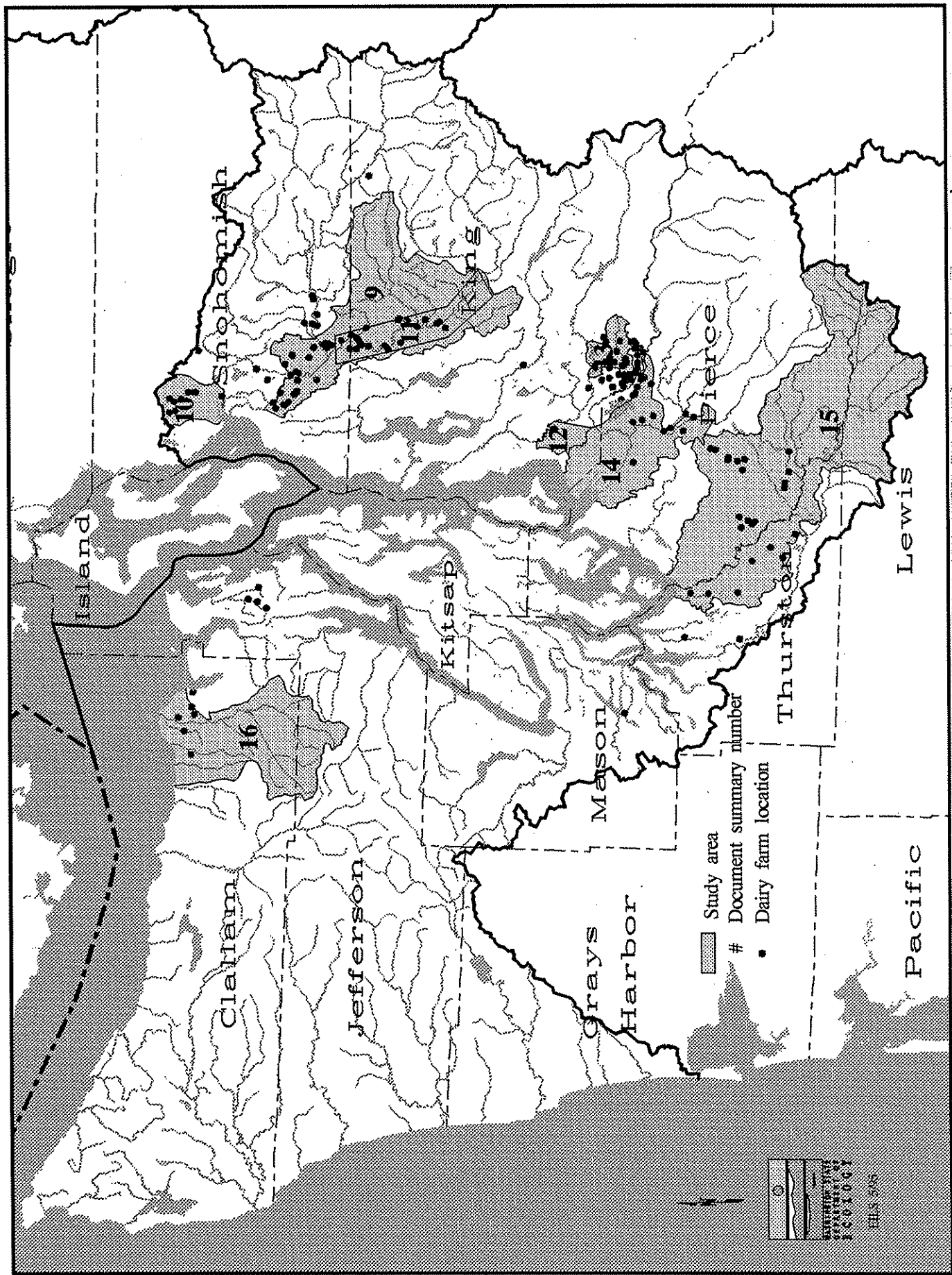


Figure 3. Study areas of documents that found dairy waste to be degrading water quality - south Puget Sound.

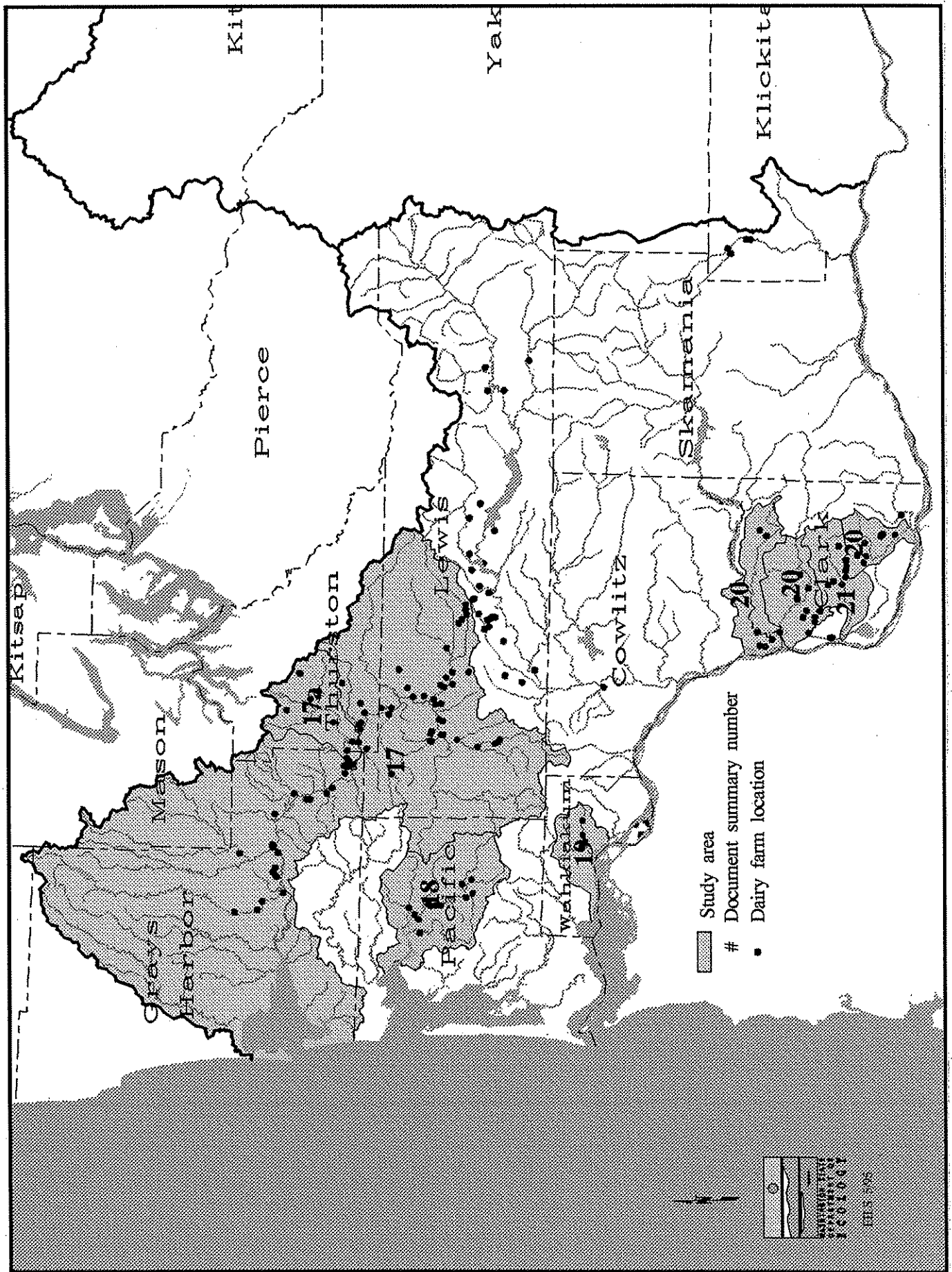


Figure 4. Study areas of documents that found dairy waste to be degrading water quality - southwest Washington.

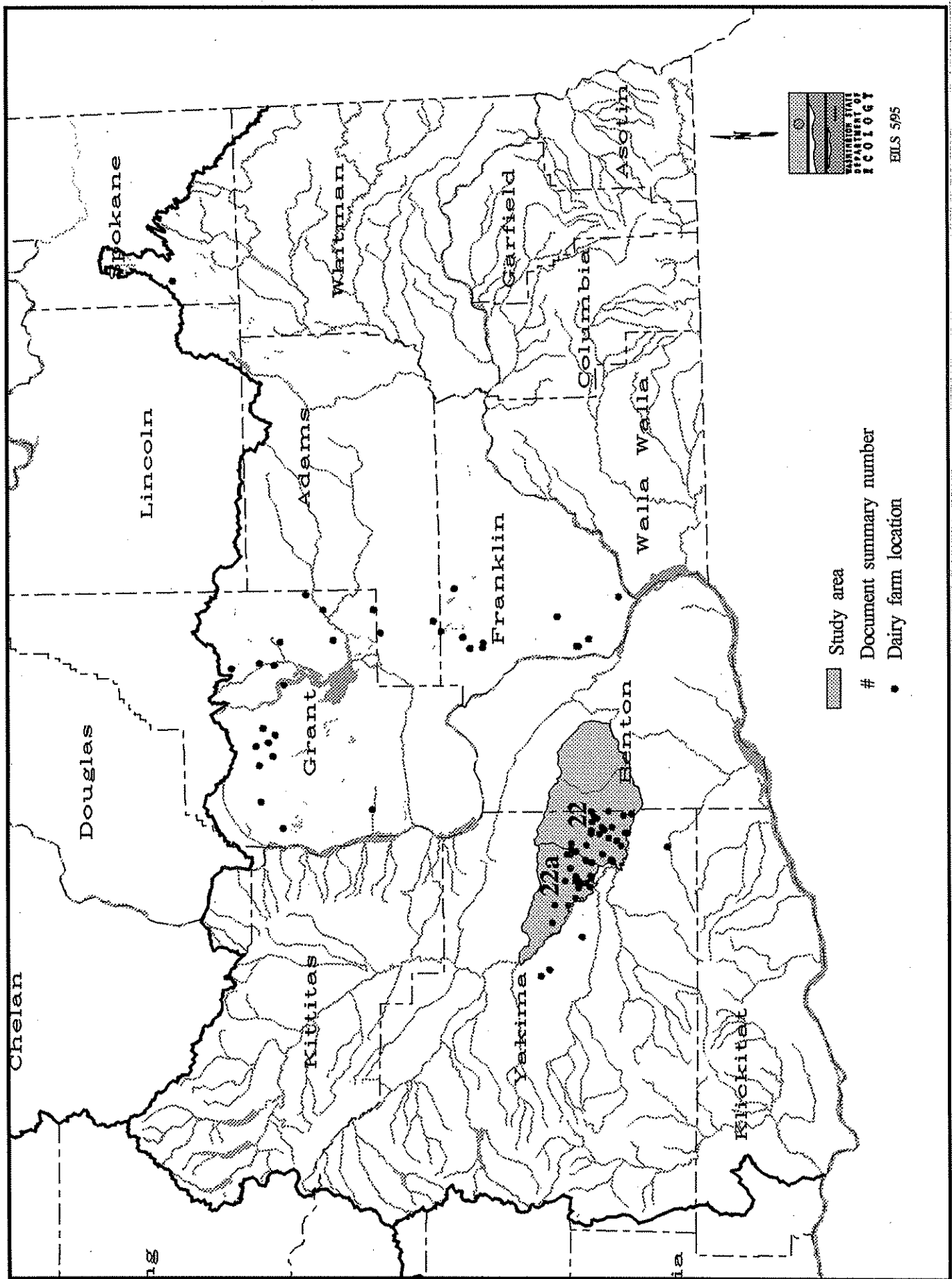


Figure 5. Study areas of documents that found dairy waste to be degrading water quality - southeast Washington.

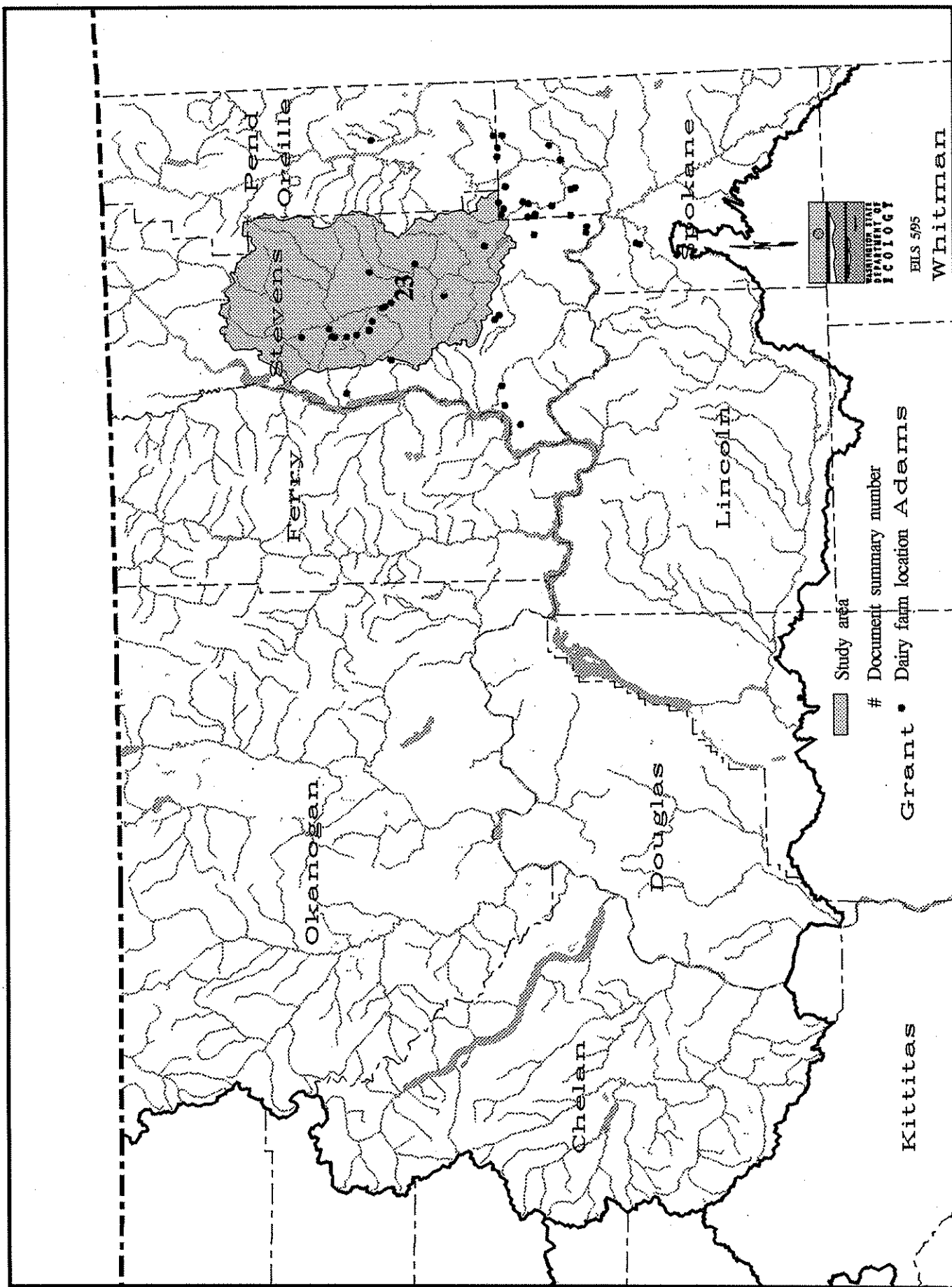


Figure 6. Study areas of documents that found dairy waste to be degrading water quality - northeast Washington.

Conclusions

The available literature clearly shows that dairies have a significant impact on the state's water quality in selected areas. The areas where dairies were most directly related to water quality problems were Johnson, Dakota, Kamm, Bertrand, Fishtrap, and Tenmile Creeks in Whatcom County; Samish River in Skagit County; and Newaukum Creek in King County. Because these areas contain high densities of dairies, it cannot be assumed that individual dairies are causing more of an impact than in other areas. Identification of these problem areas may be more a reflection of the extensive monitoring that has been conducted in those areas.

Areas that appear to be lacking information and may be candidates for additional monitoring include:

- Whatcom County. There are several dairies located along the South Fork Nooksack River, the Lummi River, and Saar Creek with no corresponding water quality studies. Information on the lower Nooksack River (mainstem) had very limited sampling near the mouth.
- Whidbey Island. A watershed planning process has been started on Whidbey Island that will address water quality problems from nonpoint sources, including dairies, but no reports are yet available.
- Enumclaw Plateau. The Enumclaw Plateau area can be seen in Figure 2 as the area of high dairy density straddling the boundary of King and Pierce counties. The Enumclaw Plateau area within Pierce County (Newaukum Creek subbasin within the Green River watershed) has been monitored as part of the Green-Duwamish Watershed Nonpoint Action Plan and is adequately addressed. However, no documents were found to cover the portion of the plateau in Pierce County, draining to the Puyallup River. The area is not covered in the Lower Puyallup Watershed plan.
- Cowlitz River. There are several dairies in the Cowlitz River basin but no water quality reports were found.
- Grant and Franklin counties. There are scattered dairies located within these counties but no water quality reports were found.

Document Summaries

Study Area #1

Sumas River Watershed

| | |
|---|--|
| Reference | Cusimano, B., 1992. Sumas River Receiving Water Study. Ecology Report, Olympia, Washington. |
| Summary | Dairy farming was cited as the probable cause of water quality criteria violations for fecal coliform and excessive nitrogen levels at the three sites upstream from the wastewater treatment plant being studied. |
| Objectives | <ol style="list-style-type: none">1) Evaluate water quality impacts resulting from wastewater discharge during the summer low flow season;2) Characterize mixing of the effluent plume and establish mixing zone boundaries for the NPDES permit; and3) Recommend permit modifications to protect the water quality of the Sumas River. |
| Background | "Ecology's Northwest Regional Office is in the process of reissuing the wastewater treatment plant (WTP) discharge permit. They requested that the Watershed Assessments Section conduct low-flow receiving water and mixing zone surveys to evaluate the impacts of the WTP discharge on river water quality." |
| Land Use | "Land use in the Sumas River watershed is primarily agriculture, specifically dairy farming. In most areas, pasture extends to the banks of the river." |
| Impaired Beneficial Uses | Beneficial uses were not discussed. |
| Water Quality | "All sampling stations upstream of the wastewater treatment plant violated the Class A criterion for fecal coliform concentrations. It is believed that nonpoint sources from agricultural activities are causing the violations. Increased nitrogen concentrations in the Sumas River are due to nitrogen loads from Johnson Creek. The nitrogen levels found in Johnson Creek are most likely due to nonpoint pollution in its drainage, specifically from dairy farming." |

Monitoring

Dates: September 24-25, 1992.

Sites: Five mainstem sites and one tributary (Johnson Creek).

Parameters tested: Temperature, pH, conductivity, dissolved oxygen, chlorophyll *a*, fecal coliform, total dissolved solids, hardness, turbidity, biochemical oxygen demand, nutrients, metals.

Study Area # 1a

Johnson Creek Watershed

| | |
|---|--|
| Reference | Overdorff, D., 1981. Water Quality Monitoring and Evaluation Program, Johnson Creek Watershed, Whatcom County, Washington, Final Report. Western Washington University, Bellingham, Washington. |
| Summary | "The data collected from this past year's study show that the water quality in the Johnson Creek watershed is below State Class A Standards in many respects. The causes of these problems can be directly attributed to the improper management of dairy wastes and the lack of adequate riparian vegetation throughout the watershed." |
| Objectives | To conduct a stream monitoring program to evaluate the overall effectiveness of conservation practices. |
| Background | In 1979, the U.S. Soil Conservation Service initiated a project to improve the water quality in north-central Whatcom County, Washington. The principal goals to be accomplished by the project were to improve the water quality in Johnson Creek to meet state Class A stream standards, and to improve the wildlife habitat within the 13,450 acre watershed by eliminating the discharge of dairy waste into the creek. The work documented in this report was part of this project. |
| Land Use | "Throughout its seven-mile length, Johnson Creek flows through dairy land. The 50 commercial dairies in the watershed average about 150 cows per farm." |
| Impaired Beneficial Uses | The report does not focus on beneficial uses; however it mentions excessive nutrients causing nuisance growth of reed canarygrass and stress on fish due to high temperatures, low dissolved oxygen levels, and siltation of gravel beds. |
| Water Quality | Class A water quality criteria were violated for temperature, pH, turbidity, dissolved oxygen, and fecal coliform. |

Monitoring

Dates: October 1980 to September 1981.

Sites: 12 sites on Johnson Creek and tributaries.

Parameters tested: Temperature, conductivity, pH, turbidity, dissolved oxygen, alkalinity, algae, invertebrate fauna, streamflow, fish population estimates, nutrients (nitrate, nitrite, ortho-phosphate), fecal coliform, total dissolved solids, chemical oxygen demand.

Study Area #1a

Johnson Creek Watershed

Reference

Dickes, B. and K. Merrill, 1990. Water Quality in the Johnson Creek Watershed after the Implementation of Best Management Practices. Washington State Department of Ecology, Olympia, Washington.

Summary

Water quality in the Johnson Creek Basin was shown to be impaired due to dairy farming. Water quality as sampled in this study violated Class A criteria for dissolved oxygen, fecal coliform, and pH. "It appears that manure continues to reach creeks in the watershed."

Objectives

- 1) Assess the present water quality of Johnson Creek and its principal tributaries related to State Class A standards;
- 2) Locate the source(s) of water quality problems, if any, and determine the respective water quality impact; and
- 3) Compare historical water quality data to current conditions in an effort to assess the effectiveness of BMP implementation.

Background

A cooperative program to improve water quality for the Johnson Creek watershed, Whatcom County, was initiated in 1979 by the Soil Conservation Service, Whatcom Conservation District, Consolidated Drainage Improvement District #31, and Ecology. Forty-five farms were involved in implementing best management practices (BMPs) to lessen water quality impairment from animal wastes. This study was to determine if the water quality had improved since the implementation of the BMPs.

Land Use

"Land use is dominated by agricultural practices. The local economy is based predominantly on dairy farming."

Impaired Beneficial Uses

Beneficial uses were not discussed.

Water Quality

Water quality violated Class A criteria for dissolved oxygen, fecal coliform, and pH.

Monitoring

Dates: Once a month during September, October, and December 1988. and January, February, March, and May 1989.

Sites: 15 stations on Johnson Creek and its two principle tributaries, Squaw and Pangborn Creeks.

Parameters tested: Temperature, conductivity, pH, dissolved oxygen, turbidity, total dissolved solids, nitrate+nitrite, ammonia, total nitrogen, total phosphorus, fecal coliform, chemical oxygen demand, biochemical oxygen demand.

Study Area #1a

Johnson Creek Watershed

| | |
|---|---|
| Reference | Dickes, B., 1992a. Johnson Creek, Whatcom County, Washington. Washington State Department of Ecology, Olympia, Washington. |
| Summary | This abbreviated study showed that water quality standard violations continued to occur in the Johnson Creek basin. "Impacts from dairy wastes would explain the elevated FC and depressed oxygen documented in this abbreviated study. However, effects from other livestock farms and failing septic systems are other possible sources." |
| Objectives | This project was conducted as an addendum to the Dakota, Bertrand, and Fishtrap Creek monitoring project (Dickes, 1992b). |
| Background | Dairy waste entering surface waters and degrading water quality has been a historical problem in Johnson Creek Watershed. The Whatcom Conservation District has been working to improve water quality in the watershed. |
| Land Use | "Land use in the Johnson Creek Watershed is dominated by agriculture, specifically dairy farming." |
| Impaired Beneficial Uses | Beneficial uses were not discussed. |
| Water Quality | Class A water quality criteria were violated at all four sites for fecal coliform, and at three of the four sites for dissolved oxygen. In addition, ammonia levels at one site equaled the chronic four-day criterion. |
| Monitoring | Dates: Four sampling events during February and March, 1992. Sites: Four sampling sites. Parameters tested: Temperature, pH, conductivity, dissolved oxygen, fecal coliform, nitrate+nitrite, ammonia. |

Study Area #2

Drayton Harbor Watershed

| | |
|---|---|
| Reference | Cook, S., 1987. Water Quality in Drayton Harbor, Whatcom County, Washington. Freshwater Assessments, Bellingham, Washington. |
| Summary | "Water quality in Drayton Harbor and California and Dakota Creeks is close to Class A standards with the exception of bacterial levels. These were shown to be dramatically high during the winter storm event and elevated by a summer storm as well. On average, bacterial levels met Class A standards in the harbor but were greatly exceeded in the creeks." |
| Objectives | To provide baseline information prior to development of Semiahmoo Resort. |
| Background | The Washington State Department of Fisheries requested the Semiahmoo Company to monitor Drayton Harbor prior to developing the Semiahmoo Resort. |
| Land Use | Land use was not discussed. |
| Impaired Beneficial Uses | Beneficial uses are not discussed, although shellfish harvesting restrictions are noted. |
| Water Quality | Neither of the creeks monitored met the state Class A criterion for dissolved oxygen from June to October. On average, the creeks greatly exceeded the state criteria for fecal coliform at the upstream sites but were within criteria at the harbor sites. |
| Monitoring | <p>Dates: August 1985 to July 1986, 19 sampling events.</p> <p>Sites: 12 sites total, two each on California and Dakota creeks (of these, one each was not tidally influenced). One site was outside the harbor in Semiahmoo Bay; the remaining sites were within the harbor.</p> <p>Parameters tested: Dissolved oxygen, pH, alkalinity, biochemical oxygen demand, total dissolved solids, turbidity, ammonia, nitrate, nitrite, phosphate, temperature, conductivity, streamflow.</p> |

Study Area #2

Drayton Harbor Watershed

| | |
|-------------------|---|
| Reference | Puget Sound Cooperative River Basin Study Team, 1991a. Drayton Harbor Watershed, Whatcom County, Washington. USDA Soil Conservation Service, Olympia, Washington. |
| Summary | "Shellfish beds presently open are threatened by bacterial contamination. Existing water quality data and resource information indicates that both commercial dairies and other livestock farms with poor management and high livestock concentrations are significant sources of bacterial contamination and nutrients. Many dairies and other livestock farms have animals in proximity to unfenced streams or drainage ditches. These areas are sources of bacteria, organic nutrients, and sediment." |
| Objectives | To provide the local watershed management committee with a characterization of the watershed and a description of the nonpoint sources of pollution and beneficial uses of water in the watershed. |
| Background | Whatcom County Council of Governments requested the Puget Sound Cooperative River Basin Team to study the watershed. The Drayton Harbor Watershed was ranked number one by the Whatcom County Watershed Ranking Committee in December 1988. |
| Land Use | Twenty-nine commercial dairies were identified in the watershed. The commercial dairies are found predominantly in the eastern portion of the watershed. "Land owned or rented by these dairies covers approximately 3,800 acres of the watershed. Dairy operations in the watershed vary in size from over 1,000 to less than 50 animal units. Most of the dairies are operated as confinement systems where only the replacement heifers and dry milk cows are pastured." |

Impaired Beneficial Uses

"Livestock are suspected to be one of the major contributors to bacterial contamination that over time has led to the closure of 500 acres of commercial shellfish beds in Drayton Harbor." Other beneficial uses described in the report include: fish resources (coho, chum, and chinook salmon; steelhead and cutthroat trout; pacific herring; smelt; commercial groundfish; crabs; and clams), wildlife habitat, wetlands, recreation, and domestic water supply. However, with the exception of shellfish harvesting, the report does not tie impairment of these uses to dairies.

Water Quality

This document summarizes water quality monitoring work done by the Washington State Departments of Health, Ecology, and Fisheries; Whatcom County Health Department; and the Institute for Watershed Studies at Western Washington University. In a study requested by the Department of Fisheries (Cook, 1987), the water quality was found to be close to Class A standards with the exception of bacterial levels. On average, bacterial levels met the Class A standard in the harbor but were greatly exceeded in the creeks. The Department of Health conducted a study of the harbor from October 1987 through June 1988. Based on the results of this study, the Department closed 500 acres of shellfish beds to harvest due to elevated bacterial levels, and left 150 acres open.

Monitoring

The water quality monitoring information in this report is a compilation of historical data and reports. No original monitoring was conducted for this study.

Study Area # 2

Drayton Harbor Watershed

Reference

Saban, L. and R. Matthews, 1992. Drayton Harbor Watershed Study Final Report. Huxley College of Environmental Studies, Western Washington University, Bellingham, Washington.

Summary

"Both the ambient monitoring data and the investigative sampling indicated that many of the tributaries flowing into Drayton Harbor, as well as the harbor itself, failed to meet freshwater or marine Class A water quality standards."

Objectives

"The objectives of the ambient water quality monitoring effort were to evaluate the existing water quality at representative sites in the watershed, to develop a baseline of water quality data for the watershed, and to develop the guidelines for long-term monitoring in the watershed." "The objective of the investigative/remedial action monitoring effort was to begin to identify the major sources of pollutants in the Drayton Harbor watershed."

Background

In 1988, the Drayton Harbor watershed was ranked as the number one priority watershed in Whatcom County by a watershed ranking committee comprised of representatives from local government agencies and affected parties. During 1991-1992, the Whatcom County Council of Governments subcontracted Western Washington University to conduct water quality assessments in the Drayton Harbor watershed. This report describes the results from that water quality assessment.

Land Use

Land use was not addressed.

Impaired Beneficial Uses

Impaired beneficial uses were not addressed.

Water Quality

"The coliform counts in both creeks were high enough to pose a potential health hazard." "The nutrient concentrations in both creeks were relatively high, at least for part of the year." "The marine coliform counts were generally quite low except during the June 1991 sampling period."

". . . The total coliform average at site 4, which is near the oyster beds, exceeded the limit of <70 colonies/100 mL recommended for shellfish culture."

Monitoring

Six sites (3 freshwater, two within Drayton Harbor, and one marine site just outside the channel to Drayton Harbor) were monitored for stream discharge, temperature (air and water), pH, dissolved oxygen, total suspended solids, turbidity, conductivity, total and fecal coliforms, nutrients, and metals.

Study Area #2

Drayton Harbor Watershed

| | |
|-------------------|---|
| Reference | Drayton Harbor Watershed Management Team, 1994. Drayton Harbor Watershed Management Plan, Review Draft. Whatcom County Council of Governments, Bellingham, Washington. |
| Summary | "Approximately half of the dairies inventoried in 1987 were having no impact on streams. The other half were observed to be having different degrees of impact on streams, and ultimately, the fish habitat they provide. Few of the commercial dairies were found to have adequate vegetation along streams or ditches." |
| Objectives | Goals: 1) Protect the beneficial uses in the Drayton Harbor Watershed which includes Drayton Harbor, California and Dakota Creeks, and the tributaries of these waters, from identified sources of nonpoint pollution; 2) Develop a watershed plan that is economically and politically feasible to implement; 3) Raise universal awareness of the beneficial uses of the watershed and the sources of nonpoint pollution which may affect them; and 4) Establish/identify an agency to monitor and implement these goals. |
| Background | In 1988 the Drayton Harbor Watershed was identified as the county's priority watershed under the Puget Sound Water Quality Authority's nonpoint program. The funding to develop the subsequent local watershed action plan was secured by the Whatcom County Council of Governments at the request of the City of Blaine and the Whatcom County Council. |
| Land Use | According to the report, there are 29 commercial dairies and four dairy replacement operations in the watershed. "Land owned or rented by operators of commercial dairies cover approximately 3,800 acres of the watershed. Of this total, about 87% is used for pasture and hayland with the rest forested or planted to crops. The dairy operations range in size from over 1,000 animal units to less than 50. Most of the dairies operate as confinement systems where only the replacement heifers and dry milk cows are pastured. Several of the dairies raise sizable numbers of dairy replacement stock." |

Impaired Beneficial Uses

"Two fish kills have been reported in the recent past, one in the North Fork (1,000 fish killed) and one in the South Fork (2,000 fish killed). Both were a result of over application of dairy animal waste on fields (Puget Sound Cooperative River Basin Team, 1991)." "Shellfish growing areas had been closed in 1985 as a result of nonpoint pollution."

Water Quality

"Water quality information shows elevated levels of fecal coliform and nutrients and low levels of dissolved oxygen in both the California and Dakota Creek basins." ". . . The commercial farms generate over 85,000 gallons of manure and the "other livestock" farms generate over 25,000 gallons daily. The 110,000 gallons of manure per day is the equivalent of waste produced by a human population of 155,000." ". . . The sites which had poor water quality in all three of the categories [FC, nutrients, and dissolved oxygen] occurred primarily in the California Creek basin in areas located near commercial dairies."

Monitoring

The water quality monitoring information in this report is a compilation of historical data and reports. No original monitoring was conducted for this study.

Study Area #2a

Dakota Creek Watershed

Reference

Whatcom County Conservation District, 1987. Agricultural Impacts on Water Resources in Dakota Creek Watershed. Lynden, Washington.

Summary

"Dairy operations appear to contribute point and nonpoint source pollution to water resources in Dakota Creek Watershed. The point source pollution on farms is largely the result of contaminated runoff piped from animal confinement areas, silos, manure storage stacks, or milking centers. Nonpoint source pollution results from field runoff where animal wastes are applied, over-application of fertilizers and wastes, runoff from animal confinement areas, and unrestricted access of livestock to streams and waterways."

Objectives

- 1) To inventory resources in the watershed and conduct on-site interviews with the major agricultural operators;
- 2) To identify sources of non-point pollution within the watershed and prioritize water quality problem areas; and
- 3) To develop watershed rehabilitation strategies.

Background

This project was part of a long-range program to assess and document nonpoint source pollution problems in Whatcom County by the Whatcom Conservation District.

Land Use

Cited in report: Agriculture is the predominant land use in the watershed, accounting for 49% of the area.

Watershed dairies: 26

Average farm size: 154 acres

Average number of 1,000 lb. animal units per farm: 235

Summary of Best Management Practices in the basin:

Number of dairies that have:

Available on-farm manure storage:

| | |
|--------------------|----------|
| 6 or more months: | 11 (44%) |
| 3 to 6 months: | 3 (12%) |
| 1 to 3 months: | 3 (12%) |
| less than 1 month: | 8 (32%) |

Milking center drainage pumped to storage: 15; drains to field, ditch, or stream: 10.

Roof water diverted or partially diverted: 13; contaminated roof water runoff: 11.

Impaired Beneficial Uses

"Dakota Creek watershed is an important shellfish and fin fish production area. Drayton Harbor provides critical habitat for the spawning of Pacific herring. Productive hard-shell clam and geoduck beds lie along the harbor. Some 500 acres of tidelands near the mouth of Dakota Creek are leased as commercial oyster beds. Poor water quality poses a serious threat to this unique resource.

Dakota Creek is among the most productive lowland salmon streams in the state. Species commonly found in the watershed's streams include coho, chinook, and chum salmon, as well as steelhead, sea-run cutthroat, and resident trout."

Water Quality

"Water quality in Dakota Creek is close to Class A standards with the exception of bacterial levels. These were shown to be dramatically high during the winter storm event and elevated by a summer storm as well. On average, bacterial levels were greatly exceeded in the creek." (*Note: the data show that dissolved oxygen criteria were also violated.*)

Monitoring

No monitoring was done by the Conservation District, but Appendix C consists of the database from Cook (1987), which includes one site on Dakota Creek (Site DK04).

Dates: August 1985 to July 1986, 19 sampling events.

Sites: One site on Dakota Creek.

Parameters tested: Dissolved oxygen, pH, alkalinity, biochemical oxygen demand, total dissolved solids, turbidity, ammonia, nitrate, nitrite, orthophosphate, temperature, conductivity, streamflow.

Study Area #2a

Dakota Creek Watershed

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| Reference | Dickes, B., 1992b. Water Quality Screening in the Dakota, Bertrand, and Fishtrap Creek Watersheds, Whatcom County, Washington. Washington State Department of Ecology, Olympia, Washington. |
| Summary | "Water quality standards violations for fecal coliform bacteria, dissolved oxygen, ammonia, and nitrate appear to be associated with agricultural land use, particularly commercial dairies." |
| Objectives | To identify water quality problem areas during wet season runoff conditions in order to assist in prioritizing areas for further investigation and targeting of source controls. |
| Background | Water quality impacts from dairies have been a recurring problem in this watershed, according to the Whatcom Conservation District. |
| Land Use | "Land use in the Dakota Creek watershed study area is mixed agricultural, rural residential, and forest." |
| Impaired Beneficial Uses | Beneficial uses were not discussed. |
| Water Quality | Class A water quality standard violations for fecal coliform and dissolved oxygen occurred primarily in the South Fork where agriculture is concentrated. A potentially toxic concentration of ammonia was found at one site in the North Fork. "Poor water quality was coincident with the presence of commercial dairies and other livestock farms." |
| Monitoring | Dates: Four sampling events between February 3, 1992, and March 16, 1992. Sites: 14 sites in basin. Parameters tested: Temperature, pH, conductivity, dissolved oxygen, fecal coliform, nitrate+nitrite, ammonia. |

Study Area #2b

Drayton Harbor Watershed

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| Reference | Washington State Department of Health, 1995. Administrative order to reclassify portions of the commercial shellfish growing area in Drayton Harbor, and associated Sanitary Survey of Drayton Harbor. Office of Shellfish Programs, Olympia, Washington. |
| Summary | The new classification scheme changes most of Drayton Harbor from "Approved" to "Prohibited" status, and is based on elevated fecal coliform levels. |
| Objectives | Notice of reclassification of shellfish beds. |
| Background | For several years, portions of the shellfish growing areas in Drayton Harbor have been classified as APPROVED for harvesting. Following a review of water quality data, an evaluation of pollution sources, and a shoreline survey in 1994, the Office of Shellfish Programs now recommends that the classification be downgraded. |
| Land Use | "As of 1994, there are only 20 commercial watershed dairies in the Dakota and California Creek drainages, of which 95% are reported to have adequate farm/manure storage, and 70% restrict access to streams. Waste applications from these dairy farms, and poor farm practices on beef and non-commercial animal farms may continue to represent a significant source of livestock wastes to receiving water streams." |
| Impaired Beneficial Uses | The beneficial use of shellfish harvesting is severely affected by this administrative order. |
| Water Quality | "Water quality data indicate that the sampling stations in the proposed PROHIBITED and RESTRICTED areas in Drayton Harbor fail to meet the fecal coliform standards set by the National Shellfish Sanitation Program. A variety of pollution sources have known or potential impact of water quality, including: . . . Farm management practices in the Dakota and California Creek watersheds . . ." |

Monitoring

Eighteen sites within Drayton Harbor were sampled for fecal coliform 15 to 19 times between the dates of 1/4/92 and 10/27/94.

Study Area #3

Lower Nooksack River Watershed and Portage Bay

Reference

Cochrane, M., 1990. Impacts of Nonpoint Pollution on Fisheries Resources; Lummi Fisheries Technical Report #91-3; Investigation of Fecal Coliform Bacteria. Lummi Fisheries Department, Lummi Indian Tribe, Bellingham, Washington.

Summary

"Results of this investigation indicate that fecal coliform levels from the Nooksack River can result in elevated levels of fecal coliform in Portage Bay waters during seasonal freshet events." "Potential sources of fecal coliform bacteria in the Nooksack River watershed are: animal wastes from manure spreading, feedlots, and range animals; and human fecal material from failed septic tanks, lack of sewage facilities, or overloaded sewage treatment plants."

Objectives

"The purpose of this investigation was to develop baseline data on fecal coliform counts in water samples and in shellfish tissue samples. Sampling was conducted primarily during high Nooksack River flows in order to investigate the effect of Nooksack River seasonal flow on Portage Bay water quality."

Background

This study was part of an overall investigation into the impacts of nonpoint pollution on fisheries resources by the Lummi Fisheries Department.

Land Use

"The lowlands of the lower Nooksack and its tributaries constitute one of the principal dairy production areas in Washington State."

Impaired Beneficial Uses

The focus of this study is bacterial contamination of shellfish in Portage Bay. "Prolonged high fecal coliform levels in the lower Nooksack River due to seasonal freshet conditions coincided with elevated fecal coliform levels in Portage Bay clam tissue after a variable period of delay."

**Water
Quality**

"Fecal coliform samples taken during this investigation demonstrated a consistent violation of Class A water quality standards at all stations."

Monitoring

During this investigation, 119 water samples from three locations and 26 clam tissue samples from one location were tested for fecal coliform from September 1988 to June 1990."

Study Area #3a

Kamm Creek Watershed

Reference

Whatcom County Conservation District, 1986a. Agricultural Impacts on Water Resources in Kamm Slough Watershed, Whatcom County, Washington. Lynden Washington.

Summary

Dairy operations contribute point and nonpoint source pollution to water resources in the Kamm Watershed. Point source pollution is largely the result of contaminated runoff from animal confinement areas, seepage from silos and manure storage stacks, and discharge of milking center waste water into waterways. Nonpoint source pollution results from field runoff where animal wastes and fertilizers are over-applied, and unrestricted access of livestock to streams and waterways.

Objectives

1) Inventory resources in the watershed and conduct on-site interviews with the major agricultural operators; 2) Identify sources of nonpoint sediment and dairy waste and prioritize water quality problem areas; 3) Monitor physical and biological water quality parameters; and 4) Develop watershed rehabilitation strategies.

Background

"The Whatcom County Conservation District has been working with the Lummi Indian Tribe, the Washington State Department of Fisheries, and the USDA Soil Conservation Service on a cooperative effort to inventory and assess agricultural related impacts in Kamm Slough Watershed."

Land Use

"Agriculture is the main industry in the watershed. Dairies, row crops, berries, nursery stock, and beef are the major farming enterprises. Dairy operations utilize over 61 percent of the watershed for pasture, hay, and silage corn production.

There are 31 dairies located within the basin, with an average size of 97 acres. The average herd size was 190 1,000-lb. animal units per farm."

Summary of Best Management Practices in the basin:

Number of dairies that have:

Available on-farm manure storage:

| | |
|--------------------|----------|
| 6 or more months: | 6 (19%) |
| 3 to 6 months: | 2 (6%) |
| 1 to 3 months: | 7 (23%) |
| less that 1 month: | 16 (52%) |

Milking center drainage pumped to storage: 2; drains to ditch or stream: 9.

Roof water diverted or partially diverted: 21; roof water mixes with contaminated slab water: 10.

Impaired Beneficial Uses

"The Kamm watershed is utilized by coho and chum salmon, steelhead, coastal cutthroat, and resident trout. Current populations of coho and chum salmon are severely depressed. Factors reducing rearing habitat productivity include low summer flows, high summer water temperatures, lack of instream cover and streamside vegetation, lack of habitat diversity in dredged areas, and marginal water quality."

Water Quality

Neither of the sites met the state Class A standard for dissolved oxygen or fecal coliform. High fecal coliform bacteria levels were consistently recorded in Kamm Slough and "appear to reflect the impact of livestock on the stream system. Nutrient input into the Kamm Slough occurs throughout the year at moderate to high levels."

Monitoring

Dates: Monthly, March 1985 to February 1986.

Sites: 2 sites.

Parameters tested: Temperature, conductivity, dissolved oxygen, turbidity, total phosphorus, nitrite, nitrate, ammonia, fecal coliform, streamflow.

Study Area #3a

Kamm Creek Watershed

Reference

Tetra Tech, 1989a. Kamm Slough Watershed: Water Quality Monitoring Results for 1988-1989. Tetra Tech, Inc, Bellevue, Washington.

Summary

"Water quality in the Kamm Slough watershed is poor to fair because of historical and current land use practices. For example, large herds of cattle were observed directly in the streams, causing bank erosion, disturbance and resuspension of bottom sediments, as well as direct loading of fecal material. The spraying of manure on fields near streams during the winter when soils are saturated was also observed."

Objectives

1) Monitor and characterize existing physical, chemical and biological conditions; 2) Identify potential nonpoint sources of pollution; 3) Provide a basis for the development and implementation of action plans; and 4) Provide baseline information with which to evaluate the effectiveness of source controls.

Background

Kamm Slough was selected as an "early action" watershed by the Washington State Department of Ecology based on its historical degradation and associated impacts on anadromous species. A Kamm Creek Watershed Management Plan has been developed for the basin.

Land Use

Land use was not discussed.

Impaired Beneficial Uses

Beneficial uses were not discussed in this report. However, the following beneficial uses were identified by the Kamm Creek Watershed Management Committee as being actually or potentially impaired by poor water quality (Whatcom County Conservation District, 1990): fish habitat, shellfish habitat, drinking water supply, and recreation.

Water Quality

"Water quality in the Kamm Slough Watershed is poor to fair. Class A water quality standards were violated for fecal coliform, dissolved oxygen and ammonia. Nutrient concentrations in Kamm Slough were relatively high compared to those in other western Washington lowland streams . . . and were considerably higher than nutrient concentrations from four nonagricultural watersheds."

Monitoring

Dates: Monthly from October 1988 to September 1989.

Sites: 5 stations.

Parameters tested: Nitrite+nitrate, nitrite, ammonia, total phosphorus, fecal coliform, total suspended solids, dissolved oxygen, temperature, conductivity, pH, streamflow.

Study Area #3a

Kamm Creek Watershed

| | |
|---------------------------------|---|
| Reference | Western Washington University, 1994. Kamm Creek Watershed Monitoring Project, First Annual Report: February 1993-November 1993, Final Draft. Institute for Watershed Studies, Bellingham, Washington. |
| Summary | "These preliminary results suggest that water quality has improved as indicated by ammonia and total phosphorus concentrations. However, lower precipitation in 1993 may also be a factor." |
| Objectives | "To: 1) compare current water quality conditions to those in 1988-1989, and 2) provide a reliable set of baseline data that can be used for comparative purposes in future studies." |
| Background | "Water quality investigations in the 1980's (Whatcom County Conservation District, 1986a; Tetra Tech, 1989a) revealed that the surface water of the Kamm Creek watershed was polluted due to extensive dairy farming operations in the watershed." ". . . To improve water quality conditions, Kamm Creek Watershed Management Plan was finalized in 1990, and the Plan is being implemented using Washington State Centennial Clean Water Funds. In addition, the U.S. Department of Agriculture designated the watershed as a Water Quality Special Project through the Agricultural Stabilization and Conservation Service and made funds available for installing structural BMPs." ". . . Fifty-nine percent of the improvements are currently in place at this time." ". . . This is the first annual report of a 5-year monitoring project." |
| Land Use | "Over 60% of the watershed is used for dairy production operations and 10% for beef cattle activities; daily animal waste production is reported to be approximately 58,000 gallons." |
| Impaired Beneficial Uses | Impaired beneficial uses were not addressed. |

Water Quality

"Fecal coliform concentrations were high except at the spring site. Nutrient concentrations were generally lower than the previous study in 1988-89, except at site 23."

". . . Low dissolved oxygen during the summer at sites 25 and 27 indicate a high oxygen demand." Class B state water quality standards were violated for dissolved oxygen at three of the four sites throughout the summer (April through October). The standard for fecal coliform was violated at all sites except the spring site.

Monitoring

Water quality was monitored at four main sites; three of them had been monitored during the 1988-89 study and the fourth was an upstream spring site. The sites were sampled every other week February 25 to November 30, 1993. In addition, for two five-week periods during the wet and dry periods, the sites were sampled twice a week (March 30 - April 29 and August 17 - September 16). Parameters measured were streamflow, pH, conductance, turbidity, total suspended solids, dissolved oxygen, soluble reactive phosphorus, total phosphorus, ammonia, nitrate/nitrite, nitrite, and fecal coliform.

Study Area #3b

Tenmile Creek Watershed

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|-------------------|---|
| Reference | Whatcom County Conservation District, 1986b. Agricultural Impacts on Water Resources in Tenmile Watershed, Whatcom County, Washington. Lynden, Washington. |
| Summary | "Dairy operations are a major source of point and nonpoint source pollution in Tenmile Watershed. Point source pollution is largely the result of contaminated runoff from animal confinement areas, seepage from silos and manure storage stacks, and discharge of milking center wastewater into waterways. Nonpoint source pollution is largely the result of runoff from fields where animal wastes are applied, over application of fertilizers and wastes, and unlimited access of livestock to streams and waterways. Water quality on balance can be described as marginal throughout most of the watershed." |
| Objectives | 1) Inventory resources in the watershed and conduct on-site interviews with the major agricultural operators; 2) Identify sources of nonpoint sediment and dairy waste and prioritize water quality problem areas, 3) Monitor physical and biological water quality parameters; and 4) Develop watershed rehabilitation strategies. |
| Background | From March 1985 to February 1986, the Whatcom Conservation District worked with the Lummi Indian Tribe, the Washington Department of Fisheries and the USDA Soil Conservation Service on a cooperative effort to inventory and assess agricultural related impacts in Tenmile Creek Watershed. |
| Land Use | <p>Cited in the report: Agriculture is the main industry in the watershed. Dairy operations utilize over 25 percent of the watershed for pasture, hay, and silage corn production. Several beef operations also utilize sizable acreage for pasture and hay production, as do many small acreage owners who run beef or horses.</p> <p>Number of dairies: 57 Average farm size: 97 acres Average number of 1,000 lb animal units per farm: 154</p> |

Summary of Best Management Practices in the basin:

Number of dairies that have:

Available on-farm manure storage:

6 or more months: 7 (12%)

3 to 6 months: 3 (5%)

1 to 3 months: 7 (12%)

less than 1 month: 40 (70%)

Milking center drainage pumped to storage: 31; drains to ditch or stream: 21.

Roof water diverted or partially diverted: 25; roof water mixes with contaminated slab water: 32.

Impaired Beneficial Uses

Fish habitat was addressed in detail in the report. Almost the entire watershed is available to anadromous fish. It is utilized by chum, coho, steelhead, and coastal cutthroat trout, as well as resident trout. The basin supported large runs of coho and chum salmon in the early 1900's, according to local residents and historical accounts. Current populations of coho and chum salmon are severely depressed.

Factors cited as reducing rearing habitat productivity included low summer flows, high summer water temperatures, lack of instream cover and streamside vegetation, lack of habitat diversity in dredged areas, and marginal water quality.

Water Quality

"High fecal coliform bacteria levels were consistently recorded in Tenmile Creek and appear to reflect the impact of livestock on the stream system. Temperature regimes occasionally exceeded the Class A state standard of 18 degrees centigrade in stream reaches with sparse vegetative canopy cover. On the average, all creeks in the study area exceeded EPA criteria for total phosphate. Nutrient input into Tenmile stream system occurs throughout the year at moderate to high levels. Water quality on balance can best be described as marginal throughout most of the watershed." *(Note: the data showed that Class A criteria were also violated for dissolved oxygen and ammonia.)*

Monitoring

Dates: Monthly, from March 1985 to February 1986.

Sites: 15 sites throughout basin.

Parameters tested: Temperature, dissolved oxygen, pH, turbidity, nutrients, fecal coliform, streamflow.

Study Area #3b

Tenmile Creek Watershed

Reference

Tetra Tech, 1989b. Tenmile Creek Watershed: Water Quality Monitoring Results for 1988 - 1989. Tetra Tech, Inc. Bellevue, Washington. Draft Report.

Summary

"Water quality in the Tenmile Creek watershed can generally be described as fair, with some areas exhibiting poor water quality. Historical and current land use practices contribute to fair to poor water quality. For example, cattle were observed directly in the streams, causing bank erosion, disturbance and resuspension of bottom sediments, as well as direct loading of fecal material. The spraying of manure on fields near streams during the winter when soils are saturated was also observed in the watershed."

Objectives

1) To monitor and characterize existing physical, chemical and biological conditions; 2) To identify potential nonpoint sources of pollution; 3) To provide a basis for the development and implementation of action plans; and 4) To provide baseline information with which to evaluate the effectiveness of source controls.

Background

Tenmile Creek was selected as an "early action" watershed based on its historical degradation and associated impacts on anadromous species. This report's initial water quality assessment provided a basis for the watershed action plan definition of nonpoint source problems and water quality goals.

Land Use

Land use was not discussed in this report.

Impaired Beneficial Uses

The following beneficial uses were mentioned: fishing, swimming, boating, fisheries and wildlife habitat, stock watering, irrigation, and drinking water. However, impairment of these beneficial uses was not discussed.

Water Quality

"Ammonia-nitrogen concentrations were high at all stations throughout the study. In comparison with other western Washington streams, Tenmile Creek exhibited some of the highest ammonia concentrations observed, as well as elevated concentrations of other nutrients. Other water quality problems in Tenmile Creek include high

concentrations of fecal coliform bacteria, nitrate + nitrite, and total phosphorus. Temperature did not appear to be a problem at any station. Dissolved oxygen concentrations were generally acceptable, except at two stations during the summer months. Lowest concentrations were 1.1 and 1.5 mg/L at these sites. A third site experienced low dissolved oxygen concentrations from May through August." Class A water quality standard violations occurred for fecal coliform, dissolved oxygen, pH, and ammonia.

Monitoring

Dates: Monthly from October 1988 to August 1989.

Sites: 8 sites plus 2 storm event sites.

Parameters tested: Nitrate + nitrite, nitrite, ammonia, total phosphorus, fecal coliform, total suspended solids, dissolved oxygen, temperature, conductivity, pH, streamflow.

Study Area #3c

Bertrand and Fishtrap Creek Watersheds

Reference

Whatcom County Conservation District, 1988. Livestock Impacts on Water Resources in Bertrand and Fishtrap Creek Watersheds. Lynden, Washington.

Summary

"Dairy operations contribute point and nonpoint source pollution to water resources in Bertrand and Fishtrap Creek watersheds. Point source pollution is largely the result of contaminated runoff from animal confinement areas, seepage from silos and manure storage stacks, and discharge of milking center waste water into waterways. Nonpoint source pollution results from field runoff where animal wastes are applied and unrestricted access of livestock to streams and waterways."

Objectives

1) Inventory resources in the watershed and conduct on-site interviews with the major livestock operators; 2) Identify sources of nonpoint pollution within the watershed and prioritize water quality problem areas; and 3) Develop watershed rehabilitation strategies.

Background

The Whatcom Conservation District conducted an assessment of agricultural impacts on water quality in the Bertrand and Fishtrap Creek watersheds between July 1987 and October 1988 as part of their long-range program to assess and document nonpoint source pollution problems in Whatcom County.

Land Use

Cited in the report: Nearly 80% of the land in the Bertrand and Fishtrap Creek watersheds is devoted to agriculture. Approximately 75% of this total is used to produce forage for livestock.

Number of dairies: 104

Average farm size: 89 acres

Average number of 1,000 lb animal units per farm: 173

Summary of Best Management Practices in the basin:

Number of dairies that have:

Available on-farm manure storage:

| | |
|--------------------|----------|
| 6 or more months: | 49 (41%) |
| 3 to 6 months: | 17 (14%) |
| 1 to 3 months: | 17 (14%) |
| less than 1 month: | 37 (31%) |

Milking center drainage pumped to storage: 70; drains to ditch or stream: 31.

Roof water diverted or partially diverted: 89; roof water mixes with contaminated slab water: 29.

Impaired Beneficial Uses

"The fishery resource is the primary beneficial use affected by water quality problems. Neither Bertrand nor Fishtrap Creeks provide the fishery resources they once did. Anadromous species still found in these waters include chum, coho, and chinook salmon, and steelhead, sea-run cutthroat trout, resident trout, and Dolly Varden. Farming activities have adversely affected fishery resources. Runoff from fields and from areas where animals are confined may contain manure. Manure lowers the dissolved oxygen in water and also contains ammonia which is extremely toxic to fish. Milk-house drains also enter these streams; the detergents, disinfectants, and milk they contain are all harmful to fish."

Water Quality

Water quality was not monitored for this report. However, the report notes: "Fish kills have occurred in recent years in the stream along Double Ditch Road and in Duffner Ditch as a result of poor water quality."

Monitoring

No monitoring was conducted for this report.

Study Area #3c

Bertrand and Fishtrap Creek Watersheds

Reference

Whatcom County Conservation District and the Whatcom County Health Department, 1990. Report on a Joint Water Quality Monitoring Project in Bertrand-Fishtrap Creek Watershed. Lynden, Washington.

Summary

"At least three factors seem to influence fecal coliform counts for the samples collected in this project: Counts were highest where dairy farms were concentrated. Sample counts were highest downstream from where livestock had direct access to streams and/or there was visible evidence of manure laden runoff from fields and livestock confinement areas after rainfall. Counts were lowest when conditions in the environment were not suitable for fecal coliform survival."

Objectives

Determine the significance of water quality problems, where and when the problems are most severe, and where the District's efforts need to be placed to improve water quality in the future.

Background

"The District had several reasons for undertaking this project: Livestock wastes, when not properly managed, pollute both surface and ground water in Whatcom County. The District, in an effort to correct and/or prevent this problem, helps farmers improve their waste management systems. To document this problem the District has written several reports on the status of livestock waste management, the latest of which is *Livestock Impacts on Water Resources in Bertrand and Fishtrap Creek Watershed* published in the fall of 1988."

Land Use

"There are over 100 dairies in this particular watershed; this is nearly a quarter of the dairy farms in the county."

Impaired Beneficial Uses

Impaired beneficial uses were not addressed.

Water Quality

The geometric mean fecal coliform bacteria counts for each site ranged from about 100 to 1,100 organisms per 100 mL.

Monitoring

Eight sites were monitored for fecal coliform once a month for 12 months. Flow was also estimated when samples were collected.

Study Area #3c

Bertrand and Fishtrap Creek Watersheds

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| Reference | Dickes, B., 1992b. Water Quality Screening in the Dakota, Bertrand, and Fishtrap Creek Watersheds, Whatcom County, Washington. Washington State Department of Ecology, Olympia, Washington. |
| Summary | "Water quality standard violations for fecal coliform bacteria, dissolved oxygen, ammonia, and nitrate appear to be associated with agricultural land use, particularly commercial dairies." |
| Objectives | To identify water quality problem areas during wet season runoff conditions in order to assist in prioritizing areas for further investigation and targeting of source controls. |
| Background | Water quality impacts from dairies have been a recurring problem in this watershed, according to the Whatcom Conservation District. |
| Land Use | "Land use in the Bertrand Creek watershed is mixed agricultural, rural residential, and forest. Land use in the Fishtrap Creek watershed is primarily agricultural, with some residential development." |
| Impaired Beneficial Uses | Beneficial uses were not discussed. |
| Water Quality | In the Bertrand Creek watershed, water quality violations for fecal coliform, dissolved oxygen, and ammonia were found in the eastern portion of the watershed, where the majority of commercial dairy operations are concentrated. In the Fishtrap Creek basin, violations of water quality criteria for fecal coliform occurred throughout the watershed. Depressed oxygen occurred in the ditches draining the central portion of the study area. Elevated ammonia concentrations were identified at several sites. |

Monitoring

Dates: Four sampling events between February 3, 1992 and March 16, 1992.

Sites: 13 sites in Bertrand basin; 17 sites in Fishtap basin.

Parameters tested: Temperature, pH, conductivity, dissolved oxygen, fecal coliform, nitrate+nitrite, ammonia.

Study Area #4

Silver Creek Watershed

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| Reference | Silver Creek Watershed Management Committee, 1990. Silver Creek Watershed Management Plan. Whatcom County Council of Governments, Bellingham, WA. |
| Summary | "The water quality in the Silver Creek watershed does not meet the criteria for Class A water. The high fecal coliform and nutrient levels occurring in Silver Creek and its tributaries are likely the result of failing septic systems, improper animal waste management, and direct unlimited access of livestock to streams." |
| Objectives | "1) Maintain the environment through clean water in Silver Creek and its tributaries; 2) develop a plan that was reasonable and which everyone could live with; and 3) attempt to develop a plan which would not result in added costs to a single one agency, individual or group." |
| Background | Silver Creek was identified as an "early action watershed" by the Puget Sound Water Quality Authority. |
| Land Use | The report identified 12 commercial farms in the watershed and many non-commercial farms. The Department of Agriculture mailing list indicates that two dairies are located in the watershed. |
| Impaired Beneficial Uses | The report discusses beneficial uses impaired by poor water quality, including fishery resources, recreational resources, livestock watering, wildlife habitat, industrial uses, drainage, irrigation, and public and domestic water supply. |
| Water Quality | Appendix C consists of a water quality assessment for the basin. "The dissolved oxygen level of 5.0 mg/L, which is considered necessary for fish survival, is not being reached at five of the 12 sites during at least part of the year. The state standard of 100 organisms/100 mL for fecal coliform bacteria has been exceeded at all but two of the sampling stations." |

Monitoring

Twelve sites within the basin were sampled 10 times between April 4, 1988, and May 5, 1989, for the following parameters: dissolved oxygen, pH, temperature, fecal coliform bacteria, total suspended solids, turbidity, ammonia, nitrate-nitrite, phosphorus (total and soluble reactive), and specific conductance.

Study Area #4

Silver Creek Watershed

| | |
|---|---|
| Reference | Institute for Watershed Studies, 1994. Silver Creek Monitoring Project, Final Report, June 1991 to June 1993. Western Washington University, Bellingham, Washington. |
| Summary | "Water quality in the Silver Creek watershed shows no improvement by chemical analyses between 1988-89 and 1992-93." |
| Objectives | "1) To evaluate the effectiveness of implemented source control programs as recommended in the Silver Creek Watershed Management Plan; 2) to permit comparisons with the existing data base obtained for the watershed between April 1988 and June 1989; and 3) to continue collecting baseline data through routine monitoring." |
| Background | This monitoring was conducted to evaluate the effectiveness of pollution source control programs recommended by the Silver Creek Watershed Management Plan. |
| Land Use | "Cattle were observed in the stream during sampling at several sites on different occasions." Dairy cattle are not differentiated from other livestock in this report, but the Department of Agriculture database shows two dairies located in the upper watershed. |
| Impaired Beneficial Uses | "The dissolved oxygen was too low to support fish during part of the year." |
| Water Quality | "The fecal coliform concentrations exceeded standards at every site at least once during the two-year sampling program." "The dissolved oxygen was too low to support fish during part of the year." |

Monitoring

Water quality was sampled at ten sites 19 times during the year, and 3 additional sites only following a storm event. During each sampling event, three samples were collected over a 48-hour period. Parameters measured consisted of specific conductance, pH, turbidity, total suspended solids, dissolved oxygen, soluble reactive phosphorus, total phosphorus, ammonia, nitrate-nitrite, and fecal and total coliform bacteria. Oil and grease were measured only for certain samples collected following a storm event.

Study Area #5

Samish River Watershed

| | |
|-------------------|--|
| Reference | Robert, V., 1987. Summary of Dairy Waste Management in the Samish River Watershed, Skagit County, WA. July 1987. Skagit Conservation District, Mt. Vernon, Washington. |
| Summary | "Dairy operations are impacting the water quality of the Samish River through point and nonpoint pollution. Examples of point source pollution are contaminated runoff from confinement areas and waste from the milking centers. Examples of nonpoint pollution are contaminated runoff from fields during winter application of manure on saturated ground and animals having uncontrolled access to the river." |
| Objectives | 1) To evaluate the water quality of the Samish River and answer the question "Is there a water quality problem in the watershed?" and 2) To identify agricultural practices, especially on dairies, that could be improved for a cleaner Samish River. |
| Background | "The Skagit Conservation District has been working to gather information on the water quality of the Samish River Watershed. The Samish River Watershed is a valuable watershed with resources assessed at over 218 million dollars." |
| Land Use | <p>Cited in the report: Agricultural areas in the basin are located mainly within the valleys of the upper watershed and the broad valley floor of the lower watershed.</p> <p>Number of dairy farms: 24 Average dairy farm size: 179 acres Total 1,000-lb. animal units: 8,832 Average number of units per farm: 368 Range of animal units per farm: 64 to 1,198</p> |

Summary of Best Management Practices in the basin:

Number of dairies that have:

Available on-farm manure storage:

| | |
|--------------------|----------|
| 6 or more months: | 12 (50%) |
| 3 to 6 months: | 2 (8%) |
| 1 to 3 months: | 3 (13%) |
| less that 1 month: | 7 (29%) |

Milking center drainage pumped to storage: 20; drains to ditch or stream: 4.

Roof water diverted or partially diverted: 14; roof water mixes with contaminated slab water: 10.

Dairies that allow direct access to waterway: 5 (21%).

Beneficial uses were not discussed.

Impaired Beneficial Uses

Water Quality

Class A criteria for fecal coliform were violated at three of the four sites tested.

Monitoring

Dates: Four sampling events from January 7, 1987 to June 29, 1987.

Sites: Four sites: two mainstem and two tributaries.

Parameters tested: Fecal coliform, total coliform.

Study Area #6

Lower Skagit River Watershed

Reference

Entranco, 1993. Lower Skagit River Basin Water Quality Study, Final Report, November 1993. Bellevue, Washington.

Summary

Dairies were found to be contributing to water quality problems in the lower Skagit River basin. Dairies, as well as other nonpoint pollution sources, were cited for elevated fecal coliform bacteria counts, low dissolved oxygen levels, and high summer temperatures. Dairies were not singled out as the main pollution source but were mentioned in conjunction with other nonpoint pollution sources.

Objectives

1) To determine existing water quality conditions in the Skagit River, Nookachamps Creek, and other tributary streams, sloughs, and drainage networks; 2) To determine if water quality standards and criteria are being met for various beneficial uses; and 3) To evaluate the need for additional point and nonpoint source pollution control in the study area.

Background

This document was initiated to address five water quality issues in the basin:

- 1) **Drinking water supply.** The City of Anacortes, which derives its drinking water from the Skagit River, was concerned about potential contaminants;
- 2) **Potential for shellfish contamination.** Skagit Bay represents one of the largest commercial shellfish growing areas in the Puget Sound region. Over 5,400 acres had been placed on restricted status by the Department of Health because of elevated fecal coliform levels;
- 3) **Fish Habitat.** The Lower Skagit River and its tributaries, sloughs, and estuaries are also important as migration corridors, spawning areas, and rearing areas for all five species of salmon, as well as steelhead and cutthroat trout. The study was intended to determine the suitability of these waters for fish rearing;
- 4) **State Water Quality Standards.** "Does the Skagit River system comply with the applicable water quality standards and criteria?"; and

5) **The Nookachamps Watershed.** Water quality data were to be used to assist in the Nookachamps Watershed Action Plan.

Land Use

"Agriculture is the principal land use in the study area. There are a total of 56 dairies in the study area with a total of 20,095 animal units (one animal unit equals approximately 1,000 pounds). Dairies and herd size are mapped and listed for each subbasin, with the majority being in the Nookachamps subbasin."

The document lists the following potential nonpoint pollution sources: commercial dairy farms; drainage district pump discharges; sanitary sewer outfalls; failing septic tanks; landfills; and wild animals and birds, including waterfowl. "Potential sources of pollution from agricultural drainage include soil erosion, fertilizers, dairy wastes, and silage runoff. There are also nine known point sources of pollution in the study area."

Impaired Beneficial Uses

Shellfish harvesting: The document states that the Skagit River is the largest source of freshwater supply to Skagit Bay and suggests that "it is also a major (but certainly not the only) source of fecal coliform bacteria threatening the viability of the shellfish industry. The water quality monitoring data clearly indicate that bacterial contamination is a significant problem throughout the study area. Nearly every stream, slough, drainage ditch (pump station), and storm drain outfall measured during the study period showed some evidence of standard violation. Potential cultural sources of fecal coliform bacteria contributing to the problem include dairy farms, failing septic tank/drainfield systems, stormwater runoff and feces from other domesticated animals. It should also be recognized that wild birds and animals are also contributors to the problem."

Fish habitat: "Conversion of this once natural and highly productive natural estuary into a now highly productive agricultural region has not occurred without some impact to natural systems and loss of significant fish rearing habitat. Water quality in the sloughs is somewhat degraded."

Water Quality

"Water quality testing revealed widespread violations of the Class A standard for fecal coliform bacteria in streams tributary to the lower Skagit River. The cause of these violations appears to be due to the cumulative influence of cultural nonpoint sources including dairy farms, urban runoff, and failing septic tank/drainfield systems."

Problems with low dissolved oxygen and high temperatures in the various tributary creeks and sloughs were attributed to a combination of low flows, nonpoint source pollution and removal of riparian vegetation.

Monitoring

Dates: December 1991 to September 1992.

Sites: Water quality was monitored at 42 sites (6 mainstem, 17 tributary and point source stations for the Skagit River; 8 slough sites for juvenile salmon rearing evaluation; and 11 Nookachamps sites).

Parameters: Flow, temperature, pH, dissolved oxygen, nitrogen (total, nitrate + nitrite, ammonia), phosphorus (total, soluble reactive), fecal coliform bacteria, metals, salinity, chlorophyll *a* conductivity, total suspended solids, alkalinity, turbidity, chloride, biochemical oxygen demand, total organic carbon, hardness, lead, copper, zinc, cadmium, oil and grease.

Study Area #7

North Skagit Bay

Reference

Washington State Department of Social and Health Services, 1988. Water Quality Study of North Skagit Bay. Office of Environmental Health, Shellfish Section. October and December 1988.

Summary

North Skagit Bay was sampled at ten sites to determine the proper shellfish classification. Samples at all ten sites failed to meet the fecal coliform criteria for commercial shellfish growing areas. Runoff from agricultural land was listed as one potential source of bacteria (as well as failing septic tanks, migratory water fowl, and point sources). The document recommended that the area be designated as "restricted."

Objectives

To collect water quality data in order to determine the proper classification for this commercial shellfish growing area.

Background

The Department of Health Shellfish Section conducted this study as part of their comprehensive shellfish-related programs.

Land Use

The study stated that over 3,000 cattle were pastured on Fir Island (the later Entranco report inventoried approximately 2,000 dairy cows in 1992 on Fir Island). It also mentioned that the problem of poor water quality is aggravated in many cases by cattle having direct access to waterways which ultimately flow into the marine waters of Skagit Bay.

Impaired Beneficial Uses

North Skagit Bay was given a shellfish harvesting classification of "restricted," which means that shellfish cannot be harvested directly but must be relayed to an approved growing area for "controlled purification" (depuration).

**Water
Quality**

The fecal coliform standard for classifying a commercial shellfish growing area as "approved" was exceeded at all 10 sites (the fecal coliform bacteria shall not exceed a geometric mean Most Probable Number (MPN) of 14 per 100 mL and not more than 10% of the samples shall exceed a MPN of 43 per 100 mL.)

Monitoring

Dates: October 1988 to December 1988.

Sites: Ten sites around North Skagit Bay.

Parameters tested: Surface salinity, surface temperature, fecal coliform.

Study Area #8

Stillaguamish Watershed

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|---------------------------------|--|
| Reference | Snohomish County Public Works, 1989. Stillaguamish Watershed Action Plan; Final October 1989. Everett, Washington. |
| Summary | "Bacteria and other pathogens as a result of poor animal keeping, waste handling, and pasture management practices pollute the Stillaguamish River. The Department of Ecology surveys identify agricultural practices as a main contributor of bacterial contamination in the lower Stillaguamish River. Agricultural practices are potentially one of the contributors to sediment in the watershed." |
| Objectives | "The main purpose of the Stillaguamish Watershed Action Plan is to reduce and ultimately eliminate entry of nonpoint source pollutants to the waters, sediments, and shorelines of the watershed." |
| Background | The Stillaguamish watershed was nominated by the Tulalip and Stillaguamish tribes to be an "early action" watershed under the Puget Sound Water Quality Management Plan because of shellfish bed contamination in Port Susan. |
| Land Use | "Agriculture, both commercial and noncommercial, is a major land use in the Stillaguamish watershed. Commercial dairy and crop farming operations are predominantly located in the floodplain areas adjacent to the Stillaguamish River." |
| Impaired Beneficial Uses | Impaired beneficial uses are not discussed. |
| Water Quality | Specific data on water quality and violations of criteria were not given. |
| Monitoring | No monitoring was conducted for this study. |

Study Area #8a

Portage Creek Watershed

Reference

Puget Sound Cooperative River Basin Study Team, 1990. Analyzing Nonpoint Source Pollution in a Puget Sound Watershed: A Cooperative Project Using Geographic Information Systems; Final Report, Geographic Information System Pilot Project in Portage Creek. Olympia, Washington

This report summarizes the water quality monitoring data from:

Plotnikoff, R. and J. Michaud, 1991. Portage Creek: Nonpoint Source Pollution Effects on Quality of the Water Resource. Ecology Report, Olympia, Washington.

Summary

"Activities such as grazing and manure or fertilizer applications in the central portion of the watershed were associated with increases in total suspended solids, total inorganic nitrogen, and fecal coliform. Nonpoint pollution seems to be coming from a variety of sources. Commercial farms often have the structural facilities in place to control nonpoint pollution. However, the survey indicated that many of the facilities are not being properly used or that management practices are inadequate. The magnitude of the nonpoint problem is judged to be roughly equal for commercial and non-commercial farms."

Objectives

- 1) Characterize nonpoint source pollution problems in the Portage Creek watershed;
- 2) Identify geographic areas and land uses that are potential contributors of nonpoint pollution;
- 3) Develop and evaluate an approach for nonpoint source characterization in the Stillaguamish basin, and identify critical information, tools and analyses; and
- 4) Develop a baseline of information for long-term analysis of problems in Portage Creek.

Background

The Stillaguamish Watershed Plan identified Portage Creek as an area for further study to identify areas of concern and to identify specific practices contributing to nonpoint pollution (Snohomish County Public Works, 1989).

Land Use

A total of 28 commercial farms occupying 2,629 acres were identified and inventoried. "Most of the commercial farms in the watershed are located in the floodplain of the Stillaguamish River. There are 13 dairies and 5 heifer operations with a total of 3,495 cattle. The largest dairy has 350 head of cattle. All of the commercial farms have some kind of waste storage facility; 7 of the 28 farms (with 76% of the animal units) have a complete waste storage system."

Impaired Beneficial Uses

Impaired beneficial uses were not discussed.

Water Quality

"Mean concentrations for fecal coliform, turbidity, and dissolved oxygen in Portage Creek violated Washington State Class A water quality standards during both the wet and dry season. Loads and concentrations were influenced by livestock access to the stream, and manure spreading."

Monitoring

From Plotnikoff and Michaud (1990):

Routine monitoring, runoff-event monitoring, and special studies were performed.

Dates: December 1988 to November 1989.

Sites: Routine monitoring: 13 sites; runoff-event monitoring: 4 sites; special studies: 4 sites for summer dissolved oxygen study, 4 sites for sediment study, 4 sites for benthic invertebrates.

Parameters tested: Flow, temperature, pH, conductivity, dissolved oxygen, total suspended solids, turbidity, nutrients, fecal coliform, biochemical oxygen demand, oil and grease, priority pollutants, macroinvertebrates.

Study Area #9

Cherry Creek, French Creek, and Marshland Slough Watersheds

Reference

Snohomish Conservation District, 1991. Snohomish Watershed Project Summary; A Cooperative Water Quality Project. Everett, Washington.

The following document is Section A of the above document, and is also published separately: Jacobsen, N. and L. Ruskell, 1991. Snohomish Watershed Final Report; A Referendum 39 Water Quality Improvement Project. Snohomish Conservation District, Everett, Washington.

The following document is Section C of the first reference and is also published separately: Thornburgh, K., K. Nelson, K. Rawson and G. Lucchetti, 1991. Snohomish System Water Quality Study 1987-90. Tulalip Fisheries Department Progress Report, Tulalip Fisheries Department, Marysville, Washington.

Summary

"This study shows that even though mainstem reaches may meet water quality standards set by the state, significant nonpoint pollution problems can occur in the tributaries. The reaches with the highest fecal coliform bacteria levels were those with the most intensive commercial farming operations."

The report found that dairies were contributing to water quality degradation in selected areas:

In the Marshland Slough area, the three upstream sites were located above agricultural areas and the fourth site was downstream. "The analysis shows a significant increase in fecal coliform levels within the reach."

"Cherry, French, and Patterson creeks showed significant increases in fecal coliform and nitrate levels from the upstream to the downstream sites. The high bacteria and nutrient levels may be explained by the direct access of animals to the stream in the Cherry Creek reach and the large holdings of animals and drainage ditching from holding facilities in French Creek. French Creek is a well-

maintained diking district and the drainage ditches carry runoff waters directly to the creek."

Objectives

Overall Project: 1) Assist dairy farms to implement agricultural best management practices (BMPs), and 2) Measure water quality to prioritize assistance to farms.

Background

The Snohomish Conservation District obtained a grant to work with farmers in the Snohomish River Basin. The goal was to reduce nonpoint pollution from agricultural activities.

Land Use

"There are 101 commercial dairies in the Snohomish Watershed with a total of 22,187 dairy cows. Fourteen dairies have long-term storage capacity and 36 have short-term storage. There are five farms with conservation plans and four of those are being implemented."

Impaired Beneficial Uses

Beneficial uses were not discussed.

Water Quality

All stream reaches sampled in this study are classified as Class A surface waters. "The mainstem Snohomish, Skykomish, and Snoqualmie River sites generally met Class A water quality standards. However, only two tributaries sampled in this study usually met Class A standards. Low dissolved oxygen and high fecal coliform levels were measured at most of the remaining sites. Turbidity was generally not a problem. Most sites met Class AA temperature standards. Levels of concern for nitrate and ortho-phosphate were identified at many of the tributary sites."

Monitoring

Dates: 67 times from August 1987 to November 1990.

Sites: 34 mainstem and tributary sites.

Parameters tested: Fecal coliform, dissolved oxygen, temperature, turbidity, pH, nutrients.

Study Area #10

Quilceda-Allen Watershed

Reference

Halpin, L., K. Nelson and K. Thornburgh, 1991. Sources of Point and Nonpoint Pollution in the Quilceda-Allen Watershed, Snohomish County, Washington. Tulalip Fisheries Department, Marysville, Washington.

Summary

"Results from the synoptic water quality sampling show that fecal coliform bacteria levels exceed Class A standards in both creeks. Stream segments with high levels of fecal coliform bacteria correspond directly to visual observations of animal access to the creek."

Objectives

1) Compile and digitize existing natural resource information to produce geographic information system (GIS) maps; 2) Identify point and nonpoint source pollution; 3) Assess water quality by conducting a synoptic survey; 4) Identify priority pollutants; and 5) Identify some of the specific sources of contamination in the watershed and make recommendations for reducing the impacts on water quality.

Background

The basin is experiencing rapid population growth and intensive residential and commercial development is occurring throughout the watershed. Water quality in the basin has been a concern.

Land Use

"Both creeks flow through agricultural, residential, and industrial lands. The upper watershed is dominated by agriculture."

Impaired Beneficial Uses

"Water quality concerns include impacts to public health and shellfish, and degradation of fish populations and their habitat. A recreational shellfish site is closed to growing and harvesting as a result of bacterial contamination. Records indicate that there are more fish kills in Quilceda and Allen Creeks than in any other watershed in Snohomish County (over 70,000 game and food fish died as a result of water pollution in these drainages)."

Water Quality

Low levels of dissolved oxygen were recorded for several sites. Fecal coliform bacteria levels exceeded Class A criteria in both creeks, and at many sites far exceeded the standard (by a factor of 10).

Monitoring

Dates: September 25-26, 1990 (Allen Creek) and October 2-4 (Quilceda Creek watershed).

Sites: Allen Creek: 17 sites; Quilceda watershed: 28 sites.

Parameters tested: Fecal coliform, temperature, dissolved oxygen, pH, turbidity, nitrate-nitrite, ortho-phosphate.

Study Area #10

Quilceda-Allen Watershed

Reference

Carroll, J. and K. Thornburgh, 1994. Draft Quilceda/Allen Watershed Characterization, Snohomish County, Washington. Snohomish County Public Works, Surface Water Management Division, Everett, Washington.

Summary

"Fecal coliform bacteria levels violate state standards throughout the watershed. The stream segments with the highest bacteria levels correlate with areas of animal access. Low levels of dissolved oxygen violate state standards in both creeks. Fish kills in the creeks were related to manure discharges, which resulted in high concentrations of ammonia and low levels of dissolved oxygen."

Objectives

To "provide the Quilceda/Allen watershed management committee and the public with a description of the physical, biological, and cultural features of the Quilceda/Allen watershed, an assessment of water quality, and a review of the regulations and policies affecting the watershed."

Background

The Quilceda/Allen watershed was ranked second-highest for Snohomish County in the Puget Sound Water Quality Authority watershed ranking process. A watershed management committee has been established for the Quilceda/Allen watershed. "This characterization will be used in preparing the problem definition and management strategy sections of the watershed plan."

Land Use

"There are 15 dairy farms in the watershed."

Impaired Beneficial Uses

"Salmon populations in both systems have been declining over the past several years." "The health of streams in the Quilceda/Allen system appears to be substantially degraded."

". . . The major impacts to aquatic habitat include:

1) Removal of riparian vegetation in some areas in the lower stream reaches, agricultural areas in the middle and upper reaches, and in logged areas in the headwater reaches.

2) Stream bank erosion from animal access to streams.

Cows kept for commercial dairy and beef farming and horses, cows, and sheep from small farms all contribute to this problem. 3) Degradation of water quality from animal waste to the streams and from runoff from roads, parking lots, yards, roof drains, and commercial and industrial land use."

Water Quality

"The water quality in the Quilceda/Allen watersheds has been degraded by a variety of land uses and nonpoint pollution sources. Farming, which occurs in the upper watershed, contributes to increased bacteria and nutrient levels in surface waters."

Monitoring

No water quality monitoring was conducted specifically for this project; the report summarizes historical data.

Study Area #10

Quilceda-Allen Watershed

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|---|--|
| Reference | Bachert, R., 1994. Inventory and Assessment of Farm Related Water Quality Problems in the Quilceda-Allen Watershed, Snohomish County, Washington (July 1, 1993 - November 5, 1993). Snohomish Conservation District and USDA Soil Conservation Service, Everett, Washington. |
| Summary | Approximately 61 percent of the farms surveyed have potential water quality problems with a "moderate" to "high" severity. |
| Objectives | 1) Identify and inventory farming enterprises, and 2) Determine potential water quality problems and make recommendations. |
| Background | A survey was conducted between July 1, 1993, and November 5, 1993, to locate and inventory all livestock-based farming enterprises in the watershed. |
| Land Use | According to the report, the basin contains 15 dairy farms, which represent about 22 percent of the total number of farms. However, "dairy animals outnumber all other livestock types combined. Consequently, they also produce the majority of the livestock waste. Most of the waste is produced by a few dairies." |
| Impaired Beneficial Uses | Beneficial uses were not discussed. |
| Water Quality | This report did not measure water quality parameters but instead relied on visual inspections of farms. Each farm was ranked according to its potential degree of impact on water quality. A farm was assigned a "high" ranking if it was determined to have a high potential adverse impact on water quality when compared to other farms. "This survey is biased to those pollution types which are readily visible and persistent; e.g., animal waste and erosion. The weather was relatively dry which did not make problems obvious." |

Rankings for dairies were not differentiated from other types of farms. Overall, 32 percent of all farms were ranked as having "high" potential water quality problems, and 29 percent as "moderate."

Monitoring

No water quality monitoring was conducted for this project.

Study Area #11

Snoqualmie River Watershed

Reference

Joy, J., G. Pelletier, R. Willms, M. Heffner, and E. Aroner, 1991. Snoqualmie River Low Flow Water Quality Assessment July - September 1989. Washington State Department of Ecology, Olympia, Washington.

Summary

"Livestock access to the river and poor manure practices were nonpoint sources clearly and routinely observed during the study. Many tributaries were not meeting Class A fecal coliform and temperature criteria. Mainstem nonpoint sources were suspected as major causes of fecal coliform loading which resulted in water quality criteria violations in the mainstem."

Objectives

Project goals were to provide the Northwest Regional Office of Ecology with basic information on water quality to evaluate sewage management plans and permits and to provide a tool to project water quality inputs from various growth scenarios. The four objectives were: 1) Evaluate the relative impact of major tributaries and point and nonpoint source discharges on current bacterial, nutrient, and dissolved oxygen conditions in the mainstem Snoqualmie River from the mouth to North Bend during summer low flow; 2) Involve local agencies and groups in appropriate portions of the project and coordinate and share data; 3) Develop a computer model that would allow the NWRO to generally predict the impact of new or expanded point source discharges on instream dissolved oxygen and trophic status during low flow conditions; 4) Make recommendations for protecting river water quality and beneficial uses from point source impacts.

Background

The Snoqualmie River Basin is experiencing rapid population growth and will likely require expanded or new sewage treatment facilities. Northwest Regional Office required basic knowledge of the water quality of the area to evaluate sewage management plans and permits.

Land Use

Land use was not described in the document. Specific nonpoint sources were mentioned in the context of discussing water quality in particular reaches.

Impaired Beneficial Uses

Impaired uses were not a focus of the report; however, it mentions that swimmers in the Snoqualmie River were usually subjected to a low risk of illness from water contact.

Water Quality

"Many tributaries were not meeting Class A fecal coliform and temperature criteria. Ames-Sikes Creek, Cherry Creek, Griffin Creek, Patterson Creek, and Kimball Creek exhibited fecal coliform problems. Ames-Sikes Creek, Tokul Creek, Patterson Creek, and the Tolt River were nutrient loading sources." (*Note: a fish hatchery was listed as a likely source of nutrients to Tokul Creek.*)

"Mainstem nonpoint sources (NPS) were suspected as major causes of fecal coliform loading which resulted in water quality criteria violations in the mainstem. They also contributed to measurable mainstem nutrient loads. Mainstem NPS inputs were most evident in selected reaches between Fall City and the mouth of the river. Livestock access and manure handling practices were the primary suspected sources, but septic tank effluents, golf course, and crop field run-off probably contributed as well."

"Significant nonpoint sources of fecal coliform loading were suspected between river mile (RM) 35.3 and RM 27.2, RM 18.3 to RM 10.7, and RM 9.8 to RM 2.7. Livestock in the river, bank-side manure storage piles, failing on-site sewage systems, and careless placement of manure guns may be contributing to nonpoint fecal loading."

Monitoring

Dates: Three week intervals between July 24 and September 5, 1989.

Sites: 18 mainstem stations and 16 tributary and point source stations.

Parameters tested: Temperature, conductivity, dissolved oxygen, pH, nutrients, total suspended solids, chloride, biological and chemical oxygen demand, total organic carbon, hardness, alkalinity, chlorophyll *a*, fecal coliform.

Study Area #12

Mill Creek Watershed

| | |
|-------------------------------------|---|
| Reference | King County Department of Public Works, 1993. Mill Creek Water Quality Management Plan. Surface Water Management Division, Seattle, Washington. |
| Summary | "Metro identifies Mill Creek as one of two streams in its survey having the poorest water quality. Studies identify the primary causes of water quality degradation as livestock trampling banks. Additionally, application of manure to pastures near streams and ditches during the winter was also identified as a significant problem that has resulted in poor water quality." |
| Objectives | Identify specific corrective measures for known water quality problems in the Mill Creek Planning Area. |
| Background | The Green River Basin had been chosen as the highest priority watershed in King County for water quality management. |
| Land Use | Agricultural areas are located in the northern portion of the basin. Dairies were not differentiated from other livestock farms, but dairies were mentioned in conjunction with enforcement actions that had been undertaken in the basin. |
| Impaired Beneficial Uses | Dairies were not tied to impairments of beneficial use. |
| Water Quality | "For many years the water quality of Mill Creek has been described as poor, based on monthly samples routinely collected by Metro at the mouth of the creek. Dissolved oxygen levels are typically below the standard of 8 mg/L and frequently are less than 3 mg/L. Other significant problems included high turbidity and elevated concentrations of fecal coliform bacteria and metals, which have exceeded water quality standards, particularly during storms. Elevated nitrate and phosphorus concentrations may contribute to primary productivity. Ammonia levels, while not exceeding the standards, are frequently high." |
| Monitoring | No monitoring was conducted specifically for this study. |

Study Area #13

Newaukum Creek Watershed

Reference

King County 1991. Green-Duwamish Watershed Nonpoint Action Plan, Final Plan. King County Environmental Division, Bellevue, Washington; and

King County Municipality of Metropolitan Seattle, 1989. Draft Green-Duwamish Watershed Nonpoint Water Quality Early-Action Plan. King County Parks, Planning and Resources Department, Seattle, Washington.

Summary

"The most significant [*nonpoint pollution*] sources are believed to be agricultural sources from the Newaukum Creek area of the Enumclaw Plateau, ..." (*the document continues to list other nonpoint sources in other areas*).

Objectives

To minimize nonpoint source water pollution, protect beneficial uses, and enhance water quality in the watershed.

Background

This plan was one of the first Nonpoint Action Plans produced in response to the nonpoint watershed management program of the 1987 Puget Sound Water Quality Management Plan.

Land Use

"The Newaukum Creek subbasin is the largest dairy producer in the state. A 1984 inventory of the basin found that there were 38 commercial livestock operations, primarily dairy farms, handling approximately 5,000 animals." Agricultural land also occurs in the Lower Green, Soos Creek, and Middle Green sub-basins.

Impaired Beneficial Uses

"Fish production of Newaukum Creek and its tributaries is limited by deterioration of riparian habitat and by water quality. Habitat in the stream corridor is deteriorated. Erosion, which is also increased by livestock with direct access to the stream banks, contributes to turbidity and sedimentation of fish breeding and feeding habitat downstream."

Water Quality

The following water quality problems were listed for the subbasins with agricultural land use: water quality criteria violations for fecal coliform (8-10 times the standard in Newaukum Creek), turbidity, and dissolved oxygen; and high nutrient levels. In addition, the report stated that in Newaukum Creek, the lack of farm Best Management Practices caused frequent violations of Class A water quality criteria for fecal coliform bacteria, nitrogen, and ammonia.

Monitoring

This report summarized the extensive monitoring that had been done on the Green River. However, no new monitoring was conducted specifically for this report.

Study Area #13

Newaukum Creek Watershed

Reference

Fritz, R., 1993. Water Quality in the Newaukum Creek Watershed After the Implementation of Best Management Practices. Muckleshoot Indian Tribe, Fisheries Department, Auburn, Washington.

Summary

"From the data collected, and visual observation, dairy wastes are directly entering Newaukum Creek and its tributaries. These waste sources must be identified and remedied."

Objectives

"1) Develop a study design and sampling protocols for two sites with BMPs in place to evaluate their effectiveness. 2) Conduct a water quality sampling program. 3) Analyze the data and interpret the results."

Background

"The Newaukum Creek Watershed Plan identified best management practices (BMPs) to improve water quality, fish habitat, and pasture land conditions." Several farm waste management BMPs were implemented over the period 1984 to 1990. The Newaukum Creek Water Quality Project was initiated in 1990 "to evaluate the effectiveness of BMP implementation in the Newaukum Creek Watershed via short-term water quality monitoring." This document summarizes the results of one task out of six of the Newaukum Creek Water Quality Project.

Land Use

One of the two BMP sites selected for this study is described as follows: "This site is a dairy operation with 170 cattle (100 milkers, 50 heifers and 20 dry cows) on 164 acres of pasture (approximately 1 animal unit per acre). In 1986, Washington State Department of Fisheries installed 3,220 feet of fencing and replanted riparian vegetation on both sides of Newaukum Creek. The site has one limited access crossing through the stream, which is 22 feet wide but very flat. In addition, the pastures are reseeded annually, and rotational grazing is practiced. An above-ground tank for dairy waste collection has been installed, but is not used."

**Impaired
Beneficial
Uses**

Beneficial uses were not addressed.

**Water
Quality**

"After analysis of the water quality data gathered throughout 1991/1992, it is conclusive that sources of non-point pollution continue to impact water quality in the Newaukum Creek Watershed. Fecal coliform concentrations in the watershed have regularly violated state water quality standards for Class A waters. Ammonia levels at the downstream sites are considerably higher (10 times) than those at the forested site. Nitrate/nitrite levels have increased since 1985 at the sites downstream from the forested site. Agricultural practices are most likely the source of these problems."

Monitoring

Water quality sampling was conducted once a month from January to December of 1992 at nine sites. The parameters measured were streamflow, dissolved oxygen, turbidity, total suspended solids, fecal coliform, nitrate/nitrite, ammonia, total phosphate, ortho-phosphate, and benthic macroinvertebrates.

Study Area #14

Lower Puyallup Watershed

Reference

Lower Puyallup Watershed Management Committee, 1992. Lower Puyallup Watershed Phase 1 Report. No location given.

Summary

In this evaluation of nonpoint pollution sources in the lower Puyallup Basin, dairies were not differentiated from other sources of agricultural pollution except in occasional references. The report summarized the Puyallup portion of Ecology's 1988 Statewide Water Quality Assessment and listed the reaches that are cited in that report as being a source of water quality impairment. Reaches mentioned that may include impacts from dairies: between the mouth and river mile 1.0 (just downstream from the point at which streams draining the high concentration of small farms in the Clark/Clear Creek sub-watershed enter the Puyallup); Wapato Creek (from runoff from pasture land); Diru Creek (runoff from pasture land, paddocks, and feedlots); Clear, Rody, and Hylebos Creeks and the White River (pasture land and animal holding areas); and Swan Creek (animal holding area).

Objectives

"The Lower Puyallup Watershed Action Plan is an effort to solve problems of nonpoint water pollution in the lower Puyallup River sub-drainage basin."

Background

The lower Puyallup Basin was selected as the top-ranking watershed in Pierce County for development of a Watershed Action Plan.

Land Use

"Agriculture is wide-spread throughout the watershed in various forms; from large acreage crop agriculture and dairying to small scale animal keeping."

Impaired Beneficial Uses

The report listed 10 beneficial uses that were threatened due to water quality problems; however, neither agriculture in general nor dairies in particular were associated with these beneficial uses.

**Water
Quality**

Water quality was summarized by subbasin based on studies done by other organizations. Water quality degradation due to dairies was not identified.

Monitoring

No water quality monitoring was conducted for this report.

Study Area #15

Nisqually River Watershed

Reference

Washington State Department of Health, 1992.
Classification Report for Hogum Bay/Nisqually Reach.
Olympia, Washington; and

Washington State Department of Ecology, 1993.
Nisqually/Hogum Bay Shellfish Growing Area; Initial
Closure Response Strategy. Shorelands and Coastal Zone
Management Program, Olympia, Washington.

Summary

Fecal coliform levels of Hogum Bay and Nisqually Reach exceeded the Department of Health's criteria for "approved" shellfish harvesting; the area was classified as "conditionally approved" with closures occurring after certain rainfall events. The Health Department study did not address potential sources; however, the Ecology report listed "agricultural activity" as the first of three "primary suspect locations and sources." Agricultural activity included dairies, vegetable farms, beef operations, and small livestock operations.

Objectives

The objective of the Health Department report was to make recommendations for the Hogum Bay/Nisqually Reach area for commercial shellfish and geoduck harvesting operations. The goals of the Ecology study was to: 1) Identify the sources of pollution impacting the Nisqually Reach/Hogum Bay commercial and recreational shellfish growing areas; 2) Initiate remedial activities to address those sources; and 3) Initiate discussion of long-term funding mechanisms and programs to address nonpoint pollution in the mid-to long-range future, including the upper watershed areas.

Background

The Ecology document was developed as a response to the downgrade in harvest classification of 520 acres of commercial shellfish beds in Nisqually Reach and Hogum Bay.

Land Use

"Agricultural activity in the area immediately adjacent to the shellfish beds includes two dairies with about 200 cows total and 18 additional farms."

**Impaired
Beneficial
Uses**

These documents focus on shellfish harvesting.

**Water
Quality**

Fecal coliform levels exceeded the Health Department's criteria for approved shellfish harvesting at 6 of the 25 marine sampling sites (geometric mean not greater than 14 organisms/100 mL with not more than 10% greater than 43 organisms/100 mL).

Monitoring

Dates: January 1989 to December 1991.

Sites: 25 marine sampling sites and 4 freshwater sites in McAllister Creek and the Nisqually River.

Parameters tested: Fecal coliform.

Study Area #16

Dungeness River Area Watershed

Reference

Puget Sound Cooperative River Basin Study Team, 1991b. Dungeness River Area Watershed, Clallam County Washington. USDA Soil Conservation Service, Olympia, Washington.

Much of the information from the above report is also summarized in:

Dungeness Watershed Management Committee and Clallam County Department of Community Development, 1993. Dungeness River Area Watershed Management Plan. Clallam County Department of Community Development, Water Quality Office, Port Angeles, Washington.

Summary

Dairy wastes were not found to be the dominant source of nonpoint pollution in this watershed. However, "significant bacterial contamination and nutrient loading from animal waste were found on both commercial and small farms with high livestock concentrations and poor management."

Objectives

To provide the local watershed management committee with a characterization of the watershed and a description of the nonpoint sources of pollution and beneficial uses of water in the watershed.

Background

The Dungeness River Area Watershed was ranked number one by the Clallam County Watershed Ranking Committee in December 1988. The ranking committee concluded the primary nonpoint source pollution problems in the watershed were agricultural activities and failing or inadequate septic systems.

Land Use

"There are four dairy farms in the watershed with a total of about 460 milk cows and nearly as many replacement stock (calves and heifers). In addition, dairy replacement heifers of 320 head are presently being raised commercially on four other operations in the watershed.

Only one dairy has adequate waste storage facilities. Two have installed fencing; on the remaining operations, livestock access to streams, ditches and wetlands is common."

Impaired Beneficial Uses

Use: The following beneficial uses were described: Fish resources, irrigation, recreation, plant life, wildlife habitat, domestic and municipal water supply, aesthetics (including a high demand for residential development near water), and a salmon hatchery.

Impairment: "The water quality survey of residents and landowners within the Dungeness River Area Watershed indicated that 91 percent of the respondents participate in activities whose value could be affected by poor water quality. Drinking water, shellfishing, consuming fish, sport fishing, and wildlife viewing were activities they identified as most affected by poor water quality. Overall, 74% felt poor water quality currently caused moderate to severe impacts on beneficial uses. The survey indicates a high concern among respondents for protection of water quality for future use."

Water Quality

"Very little sampling of surface waters has been done in the Dungeness River Area Watershed. A study by Clallum Conservation District in 1988 provided baseline data on bacterial contamination in Eastern Clallum County. Elevated levels of bacteria were found in many of the streams and ditches of the watershed. Of the 27 sites sampled, 20 (71%) did not meet the appropriate Class A or AA water quality standard for fecal coliform."

Monitoring

The report summarizes water quality monitoring conducted by the Clallum Conservation District:

Dates: "weekly" in 1988 (no dates given).

Sites: 27 sites throughout the watershed.

Parameter tested: Fecal coliform.

Study Area #17

Chehalis River Watershed

Reference

Pickett, P., 1992. Historical Data Sources and Water Quality Problems in the Chehalis River Basin. Washington State Department of Ecology, Olympia, Washington.

Information from the above report is also included in the following documents:

Chehalis River Council, 1992. Chehalis River Basin Action Plan for the Control of Nonpoint Source Pollution, Final Action Plan and Technical Supplement. Lewis County Conservation District, Chehalis, Washington.

Summary

The water quality of the Chehalis River Basin was summarized based on historical data. Dairies were not directly tied to specific water quality problems or beneficial uses. The document summarized the following findings of previous studies:

In Dillenaugh Creek, surveys observed dissolved oxygen levels below water quality criteria. Farming activities, including a dairy feedlot, were considered the primary cause of low oxygen (Crawford, 1987a).

In Salzer Creek, problems were discovered with very low dissolved oxygen and high fecal coliform levels. Farm animal management practices were identified as the predominant cause of these problems (Crawford, 1987b).

In the mainstem near Chehalis/Centralia, low dissolved oxygen levels were observed repeatedly. Cows had free access to the river in this stretch, but many other sources of oxygen demand were identified in addition to dairy waste (Devitt, 1972). Pickett adds: "It is interesting to note that . . . cows with free access could still be observed in 1991."

Objectives

To serve as a historical data review for the Chehalis River "Total Maximum Daily Load" (TMDL) study.

Background

Since at least the 1960's, the Chehalis River system had earned the attention of the Washington State Department of Ecology and its predecessor agencies because of impaired water quality. These water quality problems resulted in Ecology's decision to conduct a TMDL study of the Chehalis River system.

Land Use

"Land use in the basin encompasses a wide range of activities. Dairy, poultry, hay, row crops, and other agriculture are common in the valleys. Other land uses include timber harvesting, aquaculture, industrial development, and urban area."

Impaired Beneficial Uses

Beneficial uses were not discussed.

Water Quality

Water temperature exceeded the state water quality standard of 18°C in more than 25 percent of the samples at all four Chehalis River stations during the summer season.

Dissolved oxygen levels less than state standard were observed at Centralia and Porter.

Fecal coliform levels violated the state standard at two ambient monitoring stations nearly every year. The other two stations showed violations for several years. "This analysis indicates that violations of fecal coliform standards are a significant problem throughout the Chehalis Basin."

Monitoring

No new monitoring was conducted for this report. However, the report summarized Ecology's ambient monitoring in the basin.

Study Area #17a

Black River Watershed

Reference

Pickett, P., 1994. Black River Dry Season Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, Washington, and:

Coots, R., 1994. Black River Wet Season Nonpoint Source Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, Washington.

Summary

These studies showed that the water quality of the Black River often did not meet criteria for fecal coliform, dissolved oxygen, and temperature. Excessive levels of nutrients were also cited as a problem. The report did not relate water quality impairment directly to dairies, but did mention them as a potential source of pollutants. One of the recommendations was that dairy farms and other livestock facilities provide Best Management Practices to control the discharge of fecal coliform, total phosphorus and oxygen-demanding materials to the Black River. One specific dairy and several river reaches were identified as needing dairy BMPs.

Objectives

The objective of both studies was to develop "total maximum daily loads" (TMDLs) and recommend "waste load allocations" and "load allocations" for the Black River. The dry season TMDL study focused on dissolved oxygen and temperature, whereas the wet season TMDL focused on fecal coliform. Both studies identified existing loading sources.

Background

Ecology's Southwest Regional Office Section of the Water Quality Program requested that a Total Maximum Daily Load analysis be done for the Black River for parameters of concern.

Land Use

"A dominant activity in the Black River basin is agriculture. A number of dairies are in the basin. The largest dairies are located near the 123rd Street Bridge upstream of Littlerock, on Beaver Creek below Case Road, just north of Mima Creek and west of the Black River, and between Moon Road and the mouth. Many other sources of point and nonpoint pollution exist in the basin" (Pickett, 1994).

Impaired Beneficial Uses

Beneficial uses were not addressed.

Water Quality

The Black River is designated as a Class A waterbody. "Dissolved oxygen concentrations below the water quality criterion were widespread in the mainstem Black River and may be reduced by both natural causes and pollutant sources."

Temperatures in the Black River were often higher than the criterion of 18°C specified in the water quality criteria; however the elevated temperatures were not directly related to dairies.

Fecal coliform levels exceeded water quality criteria in the Black River mainstem and tributaries; most violations occurred in the middle reach of the Black River (river mile 10 to 16) and in the Beaver Creek subbasin. U.S. Fish and Wildlife Service survey information has identified livestock access areas and waste inputs on Beaver Creek that are likely sources of these pollutants (U.S. Fish and Wildlife Service, 1993).

Monitoring

Dates: Dry season TMDL: July to October 1991 and May to September 1992. Wet season TMDL: December to April 1991 and 1992.

Sites: Dry season TMDL: 32 mainstem sites and 15 tributary sites. Wet season TMDL: 11 mainstem sites and 3 tributary sites.

Parameters tested: Dry season TMDL: temperature, pH, dissolved oxygen, specific conductance, total suspended and dissolved solids, turbidity, specific conductance, chloride, alkalinity, dissolved silica, total organic carbon, biochemical oxygen demand (5-day and ultimate), nitrogen (ammonia, nitrate+nitrite, total), phosphorus (total, soluble reactive), chlorophyll *a*, fecal coliform bacteria, phytoplankton identification. Wet season TMDL: fecal coliform, temperature, conductivity, and river discharge.

Study Area #18

Willapa Bay Watershed

Reference

Seyferlich, H. and J. Joy, 1993. Willapa Bay Watershed; Bacterial Evaluation and Preliminary Control Strategy. Washington State Department of Ecology Publication #93-64, Olympia, Washington.

Summary

"Livestock manure, as well as on-site system failures, are thought to be the major reasons why the upper segment of Willapa River chronically exceeds fecal coliform criteria. Preliminary data analysis suggests that fecal coliform bacteria generated in the upper watershed do not necessarily reach shellfish growing areas in the bay, although river beneficial uses are threatened or impaired."

Objectives

To evaluate the bacterial problem in the Willapa Bay watershed, and to recommend an effective watershed control strategy.

Background

The past two statewide 305(b) water quality reports written by the Department of Ecology identified Willapa Bay and the Willapa River below river mile 18.2 as "water quality limited" due to fecal coliform criteria violations. Federal regulations require that Ecology perform a total maximum daily load (TMDL) evaluation in water quality-limited areas.

Land Use

"The Willapa Bay watershed is primarily intensively managed forest land. Agricultural and populated urban areas are primarily located in flood plains and along shorelines of the bay. The greatest concentration of farms is along the Willapa River, from the town of Frances downstream to Old Willapa. There are presently 15 active dairies containing approximately 4,056 dairy animals along the Willapa River. The cumulative 95,000 tons of manure produced along the Willapa River per annum is a significant potential source of bacterial pollution."

"Two dairies have registered farm plans with the Soil Conservation District and completed installation of best management practice systems to reduce bacterial pollution of water courses. One other dairy has partially completed their system, and two others are scheduled for 1994."

**Impaired
Beneficial
Uses**

The following potentially impaired beneficial uses were mentioned: domestic water consumption, primary and secondary contact recreation, and shellfish harvesting. "Willapa Bay's shellfish areas are an especially important resource in need of protection, producing over 50% of Washington's harvest. Fecal coliform bacteria pollution has been responsible for past area closures, and the recent down-classification of one-hundred acres of commercial shellfish beds near Bay Center." However, dairies are not directly implicated in this closure.

**Water
Quality**

Violations of the water quality standard for fecal coliform were widespread.

Monitoring

Data were compiled from several sources. Fecal coliform was the only parameter analyzed.

Study Area #19

Skamokawa Creek Watershed

Reference

Norton, D., 1981. Assessment of Water Quality Conditions in Skamokawa Creek, Washington. Washington State Department of Ecology, Olympia, Washington.

Summary

Water quality in the creek was found to be fairly good, with the exception being high fecal coliform levels that exceeded the state water quality criteria. These were attributed mostly to septic tanks, although it was noted that "cattle access to the creek is virtually unrestricted throughout most of the area." Also: "contamination from dairy cattle could be expected to increase during the rainy season when runoff from adjacent pastures increases."

Objectives

To determine water quality conditions within the Skamokawa basin. In addition, possible explanations for the periodic occurrence of fish kills in the creek were investigated.

Background

This study was initiated at the request of Ecology's Southwest Regional Office because of a history of periodic dissolved oxygen depletion during warm summer months, other water quality problems, and fish kills in the creek.

Land Use

"Major land uses in the area include scattered dairy farms in the lower watershed and state-owned forest lands in the upper drainage basins of Skamokawa Creek and Wilson Creek. The unincorporated town of Skamokawa is located near the mouth of the creek and contains the majority of the residences in the area."

Impaired Beneficial Uses

The only beneficial uses mentioned were fish habitat and spawning; impairment of these uses was not discussed.

Water Quality

Skamokawa Creek met all criteria for Class A waters with the exception of fecal coliform.

Monitoring

Dates: August 11-12, September 16, and October 1, 1980.

Sites: 14 sampling stations along Skamokawa Creek and several tributaries.

Parameters tested: pH, conductivity, turbidity, chemical and biochemical oxygen demand, total suspended solids, nitrogen (ammonia, nitrate+nitrite, total), phosphorus (ortho-, total), fecal coliform, chlorophyll *a*, pheophytin, macroinvertebrates.

Study Area #20

North Fork Lewis River, East Fork Lewis River, and Lacamas Creek Watersheds

Reference

Intergovernmental Resource Center, 1987. 1987 Water Quality Management Plan for Clark County, Washington. Vancouver, Washington.

Summary

"Nearly all of the streams and lakes in the urbanizing portion of Clark County experience some degree of contamination from nonpoint pollution; septic system effluent, agricultural activities, urban construction, and road run-off are the primary sources of nonpoint pollution.

Major emphasis on implementation of Best Management Practices has been focused on locally operated dairy farms. Dairies typically rely on large amounts of water to maintain sanitary operations; wash water, combined with animal waste production (as much as 85 pounds of manure per day, per animal), results in large volumes of bacteria and nutrient-enriched water."

Objectives

The primary objective of Clark County's clean water program is: "to implement practical solutions to address significant sources of water pollution in Clark County." Objectives of the plan were not given.

Background

Clark County's clean water program was initiated by the Regional Planning Council in February, 1976 and led to the development of the Water Quality Management Plan of 1978. This document represented an update and enhancement of the earlier plan, including a comprehensive needs assessment of the county's water resources (both surface and groundwater), prevention and protection measures, and extension of the planning boundary to include all of Clark County.

Land Use

Land use was not described except to list potential sources of nonpoint pollution.

Impaired Beneficial Uses

Beneficial uses were not discussed.

Water Quality

North Fork Lewis River (western portion): "Water quality characteristics of the western section of the North Fork's drainage basin reflect the area's land uses. Increased water temperature, low dissolved oxygen levels, high turbidity, excessive fecal coliform counts, and sedimentation are all symptoms experienced within the waters here. The likely sources of water quality degradation are a combination of agricultural activities and septic system effluent."

East Fork of the Lewis River (western portion): "Water quality degradation occurs throughout this area in the form of sedimentation, high turbidity, elevated fecal coliform bacteria counts, and low dissolved oxygen levels. Sources of these problems have been identified as agricultural activities, gravel operations, and septic system and sewage treatment plant effluent."

Lacamas Creek Drainage Basin: "Nearly all of the streams in the Lacamas Creek drainage basin seem to be polluted by either septic tanks or animal wastes or both."

Monitoring

Dates: January and March, 1980.

Sites: Sites on East Fork Lewis River, Burnt Bridge Creek, Salmon Creek, Lacamas Creek, and Washougal River,.

Parameters tested: pH, conductivity, turbidity, chemical and biochemical oxygen demand, total suspended solids, nitrogen (ammonia, nitrate+nitrite, total), phosphorus (ortho-, total), fecal coliform, chlorophyll *a*, pheophytin, macroinvertebrates.

Study Area #21

Salmon Creek Watershed

Reference

Clark County Conservation District, 1990. Agriculture's Contribution to Nonpoint Source Pollution in the Salmon Creek Basin. Vancouver, Washington.

Summary

"Agricultural practices are primarily responsible for the current stream conditions. Analysis of the inventory data reveals that the primary factors impacting water quality are related directly to animal access to the creek for watering."

Objectives

"This paper addresses the sources of nonpoint source pollution from agricultural operations located along Salmon Creek and its major tributaries." The study consisted of inventories of each farm in the basin and recommendations for "practices and programs which will bring water quality in the watershed to levels which will support fish habitat and safe human contact."

Background

"Clark County is developing a broad 'Master Plan' for the Salmon Creek watershed with the overall purposes of: 1) flood control, and 2) water quality improvement and protection. Concurrent with this plan, the Clark County Conservation District initiated a water quality study for Salmon Creek."

Land Use

"There are 15 dairies with about 4,026 milk cows in the basin. The herd size in the inventories ranged between 16 heifers (young, non-milk-producing cows) and 887 milking cows. The study shows that only one dairy out of 15 has a complete animal waste management system in the Salmon Creek Watershed. Two dairies have facilities to store the wastes over winter during the rainy season."

Impaired Beneficial Uses

Fish production: "Sedimentation of spawning gravels, animal waste runoff, and lack of large organic debris are the primary limiting factors to migratory fish production in Salmon Creek."

Contact Recreation: "Salmon Creek has been closed by the Health District in recent years because it was determined to be unsafe for human contact." Runoff of farm animal waste was cited as one cause of the restriction on contact recreation.

**Water
Quality**

Water quality information in this report was limited to visual observations of erosion and sedimentation.

Monitoring

No water quality monitoring was conducted for this report.

Study Area #22

Granger and Sunnyside Sub-basins

Reference

South Yakima Conservation District, 1991. Yakima River - Dairy Waste Program. (no location given)

Summary

This report summarized the dairy waste program for the South Yakima Conservation District. Detailed water quality information was not discussed; however, the report stated: "perhaps one of the more significant local water quality problems is from animal waste generated from the increased dairy operations in the lower Yakima Valley. Dairy farms impact both surface and ground water in the study area."

Objectives

To reduce dairy waste impacts by developing new dairy waste management plans and systems.

Background

The project began in 1984 to identify and mitigate nonpoint source water pollution from animal waste generated from dairy operations. The results of this assessment were used to develop a strategy to reduce animal waste impacts from dairy and feedlot operations. In 1989, Ecology awarded the district a two-year grant to continue assistance to local dairymen in the form of animal waste planning and design and implementation of improved management practices.

Land Use

"Irrigated farming is the main economic enterprise in the area. 312,798 acres are dedicated to irrigated agriculture featuring such crops as apples, sweet corn, grapes, wheat, alfalfa and irrigated pastures. Of these, irrigated pasturing as it relates to dairy and feedlot operations is by far the largest."

The document displayed the locations of dairy farms as well as the status of their waste management plan (complete or incomplete).

**Impaired
Beneficial
Uses**

"These [*dairy waste*] problems have numerous impacts and affect a multitude of uses ranging from county roads, irrigation canals, drainage outlets, degradation of air quality and the water quality of the Yakima River and other surface and groundwater resources."

**Water
Quality**

Water quality data were not included, except for a graph of fecal coliform levels along the Yakima River, some of which were above the state standard.

Monitoring

No water quality monitoring was done for this project.

Study Area #22

Granger and Sunnyside Sub-basins

Reference

Rinella, J., S. McKenzie, and G. Fuhrer, 1992. Surface-Water-Quality Assessment of the Yakima River Basin, Washington: Analysis of Available Water-Quality Data Through 1985 Water Year. United States Geological Survey, Open-File Report 91-453. Portland, Oregon.

Summary

The report cited dairies as a likely cause of water quality violations for fecal coliform and dissolved oxygen in the Granger and Sunnyside subbasins. It also cited dairies as a source of elevated nitrite-plus-nitrate and organic-nitrogen-plus-ammonia nitrogen levels.

Objectives

To describe: 1) historical water-quality conditions in the Yakima River basin, 2) long-term trends in water quality that have occurred over recent decades, and 3) relations of historical conditions and trends in water quality to natural and human factors.

Background

In 1986, the U.S. Geological Survey began testing and refining concepts for the National Water-Quality Assessment (NAWQA) Program. One of the surface-water project areas is the Yakima River basin.

Land Use

"There are 23,000 dairy cattle in 70 dairies near Sunnyside and Granger."

Impaired Beneficial Uses

Impairment of beneficial uses was not discussed, except to note the uses that the water quality standards are intended to protect.

Water Quality

Surface-water streams in the Yakima River basin are Class A, except for headwater streams (Class AA) and Sulphur Creek (Class B). The following paragraphs are excerpts from the report where dairies are mentioned, usually in conjunction with other nonpoint pollution sources:

Fecal coliform: "In the mainstem Yakima River, most of the fecal coliform exceedances of state standards occurred downstream from Granger. Areas with concentrations greater than 200 colonies per 100 mL of water include sites

at most agricultural-return flows, on the mainstem downstream from major agricultural-return flows, and in subbasins with large densities of dairies and livestock, such as Granger, Sunnyside, and Kittitas subbasins."

Nutrients: "Streams having the largest nitrite-plus-nitrate concentrations generally were in the Sunnyside subbasin, where a large number of dairies might be contributing to the enrichment. With few exceptions, sites with median organic-nitrogen-plus-ammonia-nitrogen concentrations greater than 0.6 mg/L are drains located in the Sunnyside subbasin. Their locations coincide with those sites that also have large nitrite-plus-nitrate concentrations."

Dissolved oxygen: "Potential causes of dissolved oxygen concentrations not meeting standards include: . . . increased water-use activities by man, such as irrigation, harvesting, cattle, and dairy production . . ."

Trends: "Flow-adjusted, time-trend results indicated significant increases in fecal-coliform-bacteria concentration at both sites. These trends may be associated with increases in numbers of livestock in the basin. For example, the number of dairy cattle have notably increased in the Yakima Conservation District from 1984 to 1989."

Monitoring

This report summarized several thousand water quality measurements throughout the Yakima basin from the earliest available date through water year 1985 for 42 parameters (grouped into the following categories: metals, nutrients, major constituents and solids, field measurements, radiochemical, pesticides, and sanitary quality).

Study Area #22a

Granger Sub-basin

| | |
|-------------------|---|
| Reference | Zaragoza, C., 1992. Granger Drain Monitoring Project, December 1990 - April 1992. Washington State Department of Ecology, Olympia, Washington. |
| Summary | Animal management practices were mentioned in connection with several water quality problems, including turbidity, fecal coliform, phosphorus, nitrogen, and ammonia. Although dairies were inventoried, the water quality impacts from dairies were not differentiated from those of other agricultural practices. |
| Objectives | To monitor the water quality of the sub-drains to Granger Drain, identify sources of non-point pollution, prioritize those areas for treatment, and provide a baseline of information for future comparison. |
| Background | "The United States Geological Survey has determined that Granger Drain is a major contributor of chemical and biological contaminants and suspended sediment to the Yakima River." |
| Land Use | "Nearly all of the Granger Drain is used for irrigated agriculture. There are 250 full-time farming operations and 17 dairies, with a total of 8,259 cows currently being milked (not including calves, heifers, replacement stock, etc.)." |

**Impaired
Beneficial
Uses**

Beneficial uses were not discussed, but the report mentioned that intense fisheries habitat restoration was being planned and implemented for the Granger Drain basin.

**Water
Quality**

Livestock were cited as contributing to the following violations of state water quality criteria: turbidity, fecal coliform, and ammonia. Livestock were also mentioned in conjunction with elevated nitrogen and phosphorus levels.

Monitoring

Dates: December 1990 - April 1992.

Sites: 11 sites (5 along the main drain and 6 to represent subbasins).

Parameters tested: Flow, temperature, conductivity, total dissolved solids, settleable solids, turbidity, total and fecal coliform, pH, ortho-phosphorus, total kjeldahl nitrogen, nitrate + nitrite, COD, ammonia.

Study Area #23

Dragoon Creek and Colville River Watersheds

Reference

Juul, S., 1991. An Assessment of Nonpoint Pollution on the Mid-Reaches of the Colville River and Dragoon Creek. State of Washington Water Research Center, Washington State University, Pullman, Washington.

Summary

"Major nonpoint pollution problems occurred in the Blue Creek and Dragoon Creek drainage basins during peak runoff."

Objectives

"To: 1) Determine the extent of the water quality problem, 2) Identify the sources to the extent possible, 3) Make recommendations to help mitigate future deterioration of the quality of the water in the streams, and 4) Compare the nitrogen, phosphorus, solids, and potassium concentrations of dairy lagoon samples the district analyzed using field equipment with laboratory analyses."

Background

"In Stevens County, Washington, the Colville River and Dragoon Creek have been identified as impaired water bodies by the State of Washington Department of Ecology. To help identify the possible sources of pollution, the Stevens County Conservation District applied for, and received, a grant through the Washington State Conservation Commission."

Land Use

"Land uses in the watersheds include dairy farming (there are approximately 3,000 dairy animals within the Colville River and Dragoon Creek sub-watersheds), irrigated and non-irrigated hay and crop lands, timber production, and other forest practices, hobby farms, sheep ranching, and residential development."

Impaired Beneficial Uses

Beneficial uses were not addressed.

Water Quality

The peak runoff [that] occurred in February . . . was instructive because it emphasizes the necessity of maintaining an adequate buffer zone bordering the streams. Otherwise, the waste products from the livestock, whether natural or artificially applied, along with soil particles and detrital matter, have an unimpeded route into the streams."

"The difference [in concentration and export of inorganic nitrogen between Dragoon Creek #1 and #2] may be due to a combination of: 1) a residual effect from the load entering the stream above the Dragoon Creek #1 station, 2) manure that was applied to fields between the two sampling stations, and 3) the concentration of dairies between the Dragoon Creek #1 and Dragoon Creek #2 sample stations."

"The concentrations [of orthophosphate] at Dragoon Creek #1 were significantly greater than they were at any of the other sites. This was very likely related to livestock operations upstream since the total nitrogen concentrations were also slightly higher."

"The problem with Dragoon Creek #1 drainage that caused it to get a high rating in some of the other parameters was . . . more likely due to: 1) manure that was stored or applied close to the stream, 2) a lagoon that was leaking into the stream, and/or 3) a swampy area upstream from the sample site that was flushed during high runoff." ". . . The results of the data that are available [for fecal coliform] support the previous analysis with regard to the impact of livestock operations." One of the recommendations of the study is that manure should be stored and applied away from streams.

Monitoring

Dates: July 1990 to June 1991.

Sites: Two sites on Dragoon Creek; one site each on Blue, Stensgar, Stranger, and Sheep creeks; and one site on the Colville River.

Parameters tested: Alkalinity, dissolved oxygen, specific conductance, stream discharge, temperature, total and fecal coliform bacteria, chloride, nitrogen (nitrite+nitrate, ammonia, and total), phosphorus (orthophosphate and total soluble and total phosphorus), potassium, and solids (total, fixed, volatile, and suspended solids), and turbidity.

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Appendix A
Washington State Water Quality Criteria
for Selected Parameters
(Ch. 173-201A WAC)

Appendix A. Washington State Water Quality Criteria for Selected Parameters (Ch. 173-201A WAC)

| PARAMETER | Lake Class | Class AA (Extraordinary) | | Class A (Excellent) | | Class B (Good) | | Class C (Fair) | |
|--|--|--------------------------|--|---------------------|-----------|----------------|-----------|----------------|--|
| | | Fresh | Marine | Fresh | Marine | Fresh | Marine | | |
| Fecal Coliform Bacteria Shall not exceed a geometric mean value of (number of colonies/100 mL): With not more than 10% of samples exceeding (number of colonies/100 mL): | 50 | 50 | 14 | 100 | 14 | 200 | 100 | 200 | |
| | 100 | 100 | 43 | 200 | 43 | 400 | 200 | 400 | |
| Dissolved Oxygen Shall exceed (mg/L): | no measurable decrease from natural conditions | 9.5 | 7.0 * | 8.0 | 6.0 * | 6.5 | 5.0 * | 4.0 * | |
| Temperature Shall not exceed, due to human activities (°C): (When natural conditions exceed this value, no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C.) | no measurable change from natural conditions | 16** | 13** | 18** | 16** | 21** | 19** | 22.0 | |
| pH Shall be within the range of (pH units): Human-caused variation shall be within the range of less than (pH units) | no measurable change from natural conditions | 6.5 - 8.5 | 7.0 - 8.5 | 6.5 - 8.5 | 7.0 - 8.5 | 6.5 - 8.5 | 7.0 - 8.5 | 6.5 - 9.0 | |
| | | 0.2 | | 0.5 | | 0.5 | | 0.5 | |
| Turbidity When background turbidity is 50 NTU or less, shall not exceed background turbidity by When background turbidity is more than 50 NTU, shall not have more than an increase of : | 5 | 5 | | 5 | | 10 | | 10 | |
| | 5 NTU | 10% | | 10% | | 20% | | 20% | |
| Aesthetics | Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste. | | Aesthetic values shall not be reduced by dissolved, suspended, floating, or submerged matter not attributed to natural causes, so as to affect water use or taint the flesh of edible species. | | | | | | Aesthetic values shall not be interfered with by the presence of obnoxious wastes, slimes, aquatic growths, or materials which will taint the flesh of edible species. |
| Ammonia | Ammonia criteria are dependent on the temperature and pH of the water. | | | | | | | | |

* When natural conditions, such as upwelling, occur, causing the dissolved oxygen to be depressed near or below this value, natural dissolved oxygen levels may be degraded by up to 0.2 mg/L by

** Incremental temperature increases resulting from nonpoint source activities shall not exceed 2.8°C.

Appendix B
Water Resource Inventory Area (WRIA)
and Waterbody ID Numbers
for Document Study Areas

Appendix B. Water Resource Inventory Area (WRIA) and Water Body ID Numbers for document study areas.

| WRIA | Study Area | Document | Water Body ID Numbers |
|------|-----------------------------|--|------------------------------|
| 1 | 1. Sumas River Watershed | Cusimano, B., 1992. Sumas River Receiving Water Study. Washington State Department of Ecology, Olympia, Washington. | WA-01-2010 |
| | 1a. Johnson Creek | Overdorff, D., 1981. Water Quality Monitoring and Evaluation Program, Johnson Creek Watershed, Whatcom County, Washington, Final Report. Western Washington University, Bellingham, Washington. Dickes, B. and K. Merrill, 1990. Water Quality in the Johnson Creek Watershed after the Implementation of Best Management Practices. Washington State Department of Ecology, Olympia, WA. Dickes, B., 1992a. Johnson Creek, Whatcom County, Washington. Washington State Department of Ecology, Olympia, Washington. | WA-01-2020, 2030, 2040, 2050 |
| | 2. Drayton Harbor Watershed | Cook, S., 1987. Water Quality in Drayton Harbor, Whatcom County, Washington. Freshwater Assessments, Bellingham, Washington. Puget Sound Cooperative River Basin Study Team, 1991a. Drayton Harbor Watershed, Whatcom County, Washington. USDA Soil Conservation Service, Olympia, Washington. Saban, L. and R. Matthews, 1992. Drayton Harbor Watershed Study Final Report. Huxley College of Environmental Studies, Western Washington University, Bellingham, Washington. Drayton Harbor Watershed Management Team, 1994. Drayton Harbor Watershed Management Plan, Review Draft. Whatcom County Council of Governments, Bellingham, Washington. | WA-01-0020, 1002, 1450 |
| | 2a. Dakota Creek Watershed | Whatcom County Conservation District, 1987. Agricultural Impacts on Water Resources in Dakota Creek Watershed. Lynden, Washington. Dickes, B., 1992b. Water Quality Screening in the Dakota, Bertrand, and Fishtrap Creek Watersheds, Whatcom County, Washington. Washington State Department of Ecology, Olympia, Washington. | WA-01-1002 |

Appendix B. Water Resource Inventory Area (WRIA) and Water Body ID Numbers for document study areas.

| WRIA | Study Area | Document | Water Body ID Numbers |
|------|---|--|--|
| 1 | 2b. Drayton Harbor | Washington State Department of Health, 1995. Administrative order to reclassify portions of the commercial shellfish growing area in Drayton Harbor, and associated Sanitary Survey of Drayton Harbor. Office of Shellfish Programs, Olympia, Washington. | WA-01-0020 |
| | 3. Lower Nooksack River Watershed and Portage Bay | Cochrane, M., 1990. Impacts of Nonpoint Pollution on Fisheries Resources; Lummi Fisheries Technical Report #91-3; Investigation of Fecal Coliform Bacteria. Lummi Fisheries Department, Lummi Indian Tribe, Bellingham, Washington. | WA-01-0080, 1010, 1012, 1013, 1014, 1015, 1016, 1101, 1102, 1103, 1104, 1110, 1111, 1115, 1116, 1117, 1118, 1119 |
| | 3a. Kamm Creek Watershed | Whatcom County Conservation District, 1986a. Agricultural Impacts on Water Resources in Kamm Slough Watershed, Whatcom County, Washington. Lynden Washington. Tetra Tech, 1989a. Kamm Slough Watershed: Water Quality Monitoring Results for 1988-1989. Tetra Tech, Inc. Bellevue, Washington. Western Washington University, 1994. Kamm Creek Watershed Monitoring Project, First Annual Report: February 1993-November 1993, Final Draft. Institute for Watershed Studies, Bellingham, Washington. | WA-01-1015, 1016 |
| | 3b. Tenmile Creek Watershed | Whatcom County Conservation District, 1986b. Agricultural Impacts on Water Resources in Tenmile Watershed, Whatcom County, Washington. Lynden, Washington. Tetra Tech, 1989b. Tenmile Creek Watershed: Water Quality Monitoring Results for 1988 - 1989. Tetra Tech, Inc. Bellevue, Washington. | WA-01-1012 |
| | 3c. Bertrand and Fishtrap Creek Watersheds | Whatcom County Conservation District, 1988. Livestock Impacts on Water Resources in Bertrand and Fishtrap Creek Watersheds. Lynden, Washington. Whatcom County Conservation District and the Whatcom County Health Department, 1990. Report on a Joint Water Quality Monitoring Project in Bertrand-Fishtrap Creek Watershed. Lynden, Washington. | WA-01-1110, 1111, 1115, 1116, 1117, 1118, 1119 |

Appendix B. Water Resource Inventory Area (WRIA) and Water Body ID Numbers for document study areas.

| WRIA | Study Area | Document | Water Body ID Numbers |
|------|---|--|--|
| 1 | 3c. Bertrand and Fishtrap Creek Watersheds (cont.) | Dickes, B., 1992b. Water Quality Screening in the Dakota, Bertrand, and Fishtrap Creek Watersheds, Whatcom County, Washington. Washington State Department of Ecology, Olympia, Washington. | |
| | 4. Silver Creek Watershed | Silver Creek Watershed Management Committee, 1990. Silver Creek Watershed Management Plan. Whatcom County Council of Governments, Bellingham, WA. Institute for Watershed Studies, 1994. Silver Creek Monitoring Project, Final Report, June 1991 to June 1993. Western Washington University, Bellingham, Washington. | WA-01-1101, 1102, 1103, 1104 |
| 3 | 5. Samish River Watershed 6. Lower Skagit River Watershed 7. North Skagit Bay | Robert, V., 1987. Summary of Dairy Waste Management in the Samish River Watershed, Skagit County, Washington. July 1987. Skagit Conservation District, Mt. Vernon, Washington. Entranco, 1993. Lower Skagit River Basin Water Quality Study, Final Report, November 1993. Bellevue, Washington. Washington State Department of Social and Health Services, 1988. Water Quality Study of North Skagit Bay. Office of Environmental Health, Shellfish Section. October and December 1988. | WA-03-2010 WA-03-1010, 1011, 1012, 1015, 1016, 1017, 1018, 1019 WA-PS-0010 |
| 5 | 8. Stillaguamish River Watershed 8a. Portage Creek Watershed | Snohomish County Public Works, 1989. Stillaguamish Watershed Action Plan; Final, October 1989. Everett, Washington. Puget Sound Cooperative River Basin Study Team, 1990. Analyzing Nonpoint Source Pollution in a Puget Sound Watershed: A Cooperative Project Using Geographic Information Systems; Final Report, Geographic Information System Pilot Project in Portage Creek. Plotnikoff, R. and J. Michaud, 1991. Portage Creek: Nonpoint Source Pollution Effects on Quality of the Water Resource. Washington State Department of Ecology, Olympia, Washington. | WA-05-1010, 1012, 1015, 1016, 1020, 1021, 1022, 1023, 1024, 1025, 1026, 1030, 1040, 1050 WA-05-1015 |

Appendix B. Water Resource Inventory Area (WRIA) and Water Body ID Numbers for document study areas.

| WRIA | Study Area | Document | Water Body ID Numbers |
|------|--|---|--|
| 7 | 9. Cherry Creek, French Creek, and Marshland Slough Watersheds | <p>Snohomish Conservation District, 1991. Snohomish Watershed Project Summary; A Cooperative Water Quality Project. Everett, Washington.</p> <p>Jacobsen, N. and L. Ruskell, 1991. Snohomish Watershed Final Report; A Referendum 39 Water Quality Improvement Project. Snohomish Conservation District, Everett, Washington.</p> <p>Thornburgh, K., K. Nelson, K. Rawson and G. Lucchetti, 1991. Snohomish System Water Quality Study 1987-90. Tulalip Fisheries Department Progress Report, Tulalip Fisheries Department, Marysville, Washington.</p> | WA-07-1010, 1011, 1012, 1015, 1020, 1030, 1040, 1050, 1052, 1060, 1062, 1064, 1066, 1068, 1070, 1080, 1090, 1100, 1101, 1102, 1104, 1106, 1108, 1110, 1120, 1130, 1140, 1150, 1160, 1163, 1170, 1180, 1190, 1200, 1210, 1220 |
| | 10. Quilceda-Allen Watershed | <p>Halpin, L., K. Nelson and K. Thornburgh, 1991. Sources of Point and Nonpoint Pollution in the Quilceda-Allen Watershed, Snohomish County, Washington. Tulalip Fisheries Department, Marysville, Washington.</p> <p>Carroll, J. and K. Thornburgh, 1994. Draft Quilceda/Allen Watershed Characterization, Snohomish County, Washington. Snohomish County Public Works, Surface Water Management Division, Everett, Washington.</p> <p>Bachert, R., 1994. Inventory and Assessment of Farm Related Water Quality Problems in the Quilceda-Allen Watershed, Snohomish County, Washington (July 1, 1993 - November 5, 1993). Snohomish Conservation District & USDA Soil Conservation Service, Everett</p> | WA-07-1012, 1015 |
| | 11. Snoqualmie River | Joy, J., G. Pelletier, R. Willms, M. Heffner, and E. Aroner, 1991. Snoqualmie River Low Flow Water Quality Assessment July - September 1989. Washington State Department of Ecology, Olympia, Washington. | WA-07-1060, 1062, 1064, 1066, 1068, 1070, 1080, 1090, 1100, 1101, 1102, 1104, 1106, 1108, 1110, 1120, 1130, 1140, 1150 |

Appendix B. Water Resource Inventory Area (WRIA) and Water Body ID Numbers for document study areas.

| WRIA | Study Area | Document | Water Body ID Numbers |
|------|-------------------------------|--|--|
| 9 | 12. Mill Creek Watershed | King County Department of Public Works, 1993. Mill Creek Water Quality Management Plan. Surface Water Management Division, Seattle, Washington. | WA-09-1022 |
| | 13. Newaukum Creek Watershed | King County 1991. Green-Duwamish Watershed Nonpoint Action Plan, Final Plan. King County Environmental Division, Bellevue, Washington. King County Municipality of Metropolitan Seattle, 1989. Draft Green-Duwamish Watershed Nonpoint Water Quality Early-Action Plan. King County Parks, Planning and Resources Department, Seattle, Washington. Fritz, R., 1993. Water Quality in the Newaukum Creek Watershed After the Implementation of Best Management Practices. Muckleshoot Indian Tribe, Fisheries Department, Auburn, Washington. | WA-09-1028 |
| 10 | 14. Lower Puyallup Watershed | Lower Puyallup Watershed Management Committee, 1992. Lower Puyallup Watershed Phase 1 Report. (no location given) | WA-10-0020, 0030, 1010, 1011, 1012, 1013, 1015, 1020, 1021, 1022, 1025, 1026, 1027, 1028, 1030, 1050, 1060, 1062 |
| 11 | 15. Nisqually River Watershed | Washington State Department of Health, 1992. Classification Report for Hogum Bay/Nisqually Reach. Olympia, Washington. Washington State Department of Ecology, 1993. Nisqually/Hogum Bay Shellfish Growing Area; Initial Closure Response Strategy. Shorelands and CZM Program, Olympia, Washington. | WA-11-1010, 2000 |
| 18 | 16. Dungeness River Watershed | Puget Sound Cooperative River Basin Study Team, 1991b. Dungeness River Area Watershed, Clallam County Washington. USDA Soil Conservation Service, Olympia, Washington. | WA-18-1010, 1012, 1020, 1100, 1300 |

Appendix B. Water Resource Inventory Area (WRIA) and Water Body ID Numbers for document study areas.

| WRIA | Study Area | Document | Water Body ID Numbers |
|--------|---|--|---|
| 22, 23 | 17. Chehalis River Watershed | Pickett, P., 1992. Historical Data Sources and Water Quality Problems in the Chehalis River Basin. Washington State Department of Ecology, Olympia, Washington. Chehalis River Council, 1992. Chehalis River Basin Action Plan Technical Supplement. Lewis County Conservation District, Chehalis, Washington. Chehalis River Council, 1992. Chehalis River Basin Action Plan for the Control of Nonpoint Source Pollution, Final Action Plan. Lewis County Conservation District, Chehalis, Washington. | WA-22-0020, 0030, 1010, 1020, 1030, 1040, 1050, 2010, 2020, 3010, 3020, 3030, 4010, 4020, 4030, 4040, 4042, 4045, 4050, 4060, 4070, 4080, 4085, 4090, 5000, WA-23-1010, 1014, 1015, 1017, 1018, 1019, 1020, 1023, 1024, 1027, 1028, 1030, 1043, 1045, 1050, 1060, 1070, 1080, 1090, 1100, 1102, 1104, 1106, 1108, 1110, 2010, 2020, 2021, 4025 |
| | 17a. Black River Watershed | Pickett, P., 1994. Black River Dry Season Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, WA. Coots, R., 1994. Black River Wet Season Nonpoint TMDL. Washington State Department of Ecology, Olympia, Washington. | WA-23-1015, 2010, 2020, 2021 |
| 24 | 18. Willapa Bay Watershed | Seyferlich, H. and J. Joy, 1993. Willapa Bay Watershed: Bacterial Evaluation and Preliminary Control Strategy. Washington State Department of Ecology Publication #93-64, Olympia, Washington. | WA-24-0020, 1010, 1011, 1020, 1030, 1050, 1080, 2010, 2020, 2030, 2035, 3010, 3020, 3040, 4000, 4100, 4200, 5000, 5100, 5200 |
| 25 | 19. Skamokawa Creek Watershed | Norton, D., 1981. Assessment of Water Quality Conditions in Skamokawa Creek, Washington. Washington State Department of Ecology, Olympia, Washington. | WA-25-2010 |
| 27, 28 | 20. North Fork Lewis River, East Fork Lewis River, and Lacamas Creek Watersheds | Intergovernmental Resource Center, 1987. 1987 Water Quality Management Plan for Clark County, Washington. Vancouver, Washington. | WA-27-2040 (North Fork Lewis River - western portion); WA-27-2020, 2022, 2024, 2026 (East Fork Lewis River - western portion); WA-28-2020, 2023, 2024, 2025, 2026 (Lacamas Creek) |

Appendix B. Water Resource Inventory Area (WRIA) and Water Body ID Numbers for document study areas.

| WRIA | Study Area | Document | Water Body ID Numbers |
|--------|---|--|---|
| 28 | 21. Salmon Creek Watershed | Clark County Conservation District, 1990. Agriculture's Contribution to Nonpoint Source Pollution in the Salmon Creek Basin. Vancouver, Washington. | WA-28-1020, 1023, 1025, 1026, 1027 |
| 37 | 22. Granger and Sunnyside Subbasins | South Yakima Conservation District, 1991. Yakima River - Dairy Waste Program. (no location given) | WA-37-1024 |
| | | Rinella, J., S. McKenzie, and G. Fuhrer, 1992. Surface-Water-Quality Assessment of the Yakima River Basin, Washington: Analysis of Available Water-Quality Data Through 1985 Water Year. USGS Open-File Report 91-453. Portland, OR. | WA-37-1024, 1030 |
| | 22a. Granger Subbasin | Zaragoza, C., 1992. Granger Drain Monitoring Project, December, 1990 - April, 1992. Washington State Department of Ecology, Olympia, Washington. | WA-37-37-1024 |
| 55, 59 | 23. Dragoon Creek and Colville River Watersheds | Juul, S., 1991. An Assessment of Nonpoint Pollution on the Mid-Reaches of the Colville River and Dragoon Creek. State of Washington Water Research Center, Washington State University, Pullman, Washington. | WA-55-1012 (Dragoon Creek), WA-59-1010 (Colville River) |

Appendix C

Document Sources

Bibliographies and listings

- Bibliographies for the Washington State Department of Ecology, Environmental and Laboratory Services Program, for the period 1969 through 1993.
- Computer listing of United States Geological Survey reports and maps related to water resources of Washington State, through 1993.
- Publications list for the State of Washington Water Research Center, University of Washington and Washington State University, through 1993.
- "Significant Watershed Activity Survey" by Lloyd Moody, State of Washington, Office of the Governor, August 1993.
- Database printout from the Washington State Department of Ecology, Water Quality Financial Assistance Program of grant information with keywords "watershed" and "agriculture" 1994.
- List of Puget Sound Water Quality Authority watershed studies.
- Summary of research and monitoring activities in the Stillaguamish River Watershed by Libby Halpin, Environmental Coordinator, Tulalip Fisheries Department, 1991.

Library searches

- Washington State Department of Ecology libraries (main, Environmental Investigations and Laboratory Services, Water Quality Financial Assistance).
- Washington State Conservation Commission library.

Contacts

Western Washington University, Institute of Watershed Studies

Cooperative Extension, Washington State University, Whatcom County

Washington State Conservation Commission

Local Conservation Districts and Natural Resource Conservation Service offices:

Clark County

King

Pacific

Pierce County

Skagit

Snohomish

Spokane County

Stevens County

Thurston

Whatcom

South Yakima

King County/Metro

Puget Sound Water Quality Authority

Ecology Regional Offices (Northwest, Southwest, Central, Eastern)

Washington State Department of Health

Muckleshoot Indian Tribe, Fisheries Department

Lummi Indian Business Council

U.S. Environmental Protection Agency, Region 10