Quality Assurance Project Plan

Yakima Area Creeks Fecal Coliform Total Maximum Daily Load Study

by
Joe Joy

Washington State Department of Ecology
Environmental Assessment Program
Olympia, Washington 98504-7710

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303(d) Listings Addressed in This Study:

Cowiche Creek (WA-38-1015): Fecal Coliform
Cowiche Creek, North Fork (WA-38-1016): Fecal Coliform
Cowiche Creek, South Fork (WA-38-1017): Fecal Coliform
Moxee Drain (WA-37-1048): Fecal Coliform
Wide Hollow Creek (WA-37-1047): Fecal Coliform

User Study ID: YUTTMDL

Approvals

Approved by: — December 30, 2004
Ryan Anderson, Client Staff Contact, Central Regional Office — Date

Approved by: — December 30, 2004
Acting Unit Supervisor, Water Quality Program, CRO — Date

Approved by: — January 3, 2005
Tom Tebb, Section Manager, Central Regional Office — Date

Approved by: — December 16, 2004
Joe Joy, Project Manager, Watershed Ecology Section — Date

Approved by: — December 30, 2004
Nuri Mathieu, Field Lead, Watershed Ecology Section — Date

Approved by: — December 20, 2004
Karol Erickson, Unit Supervisor, Nonpoint Studies Unit — Date

Approved by: — December 30, 2004
Will Kendra, Section Manager, Watershed Ecology Section — Date

Approved by: — January 3, 2005
Stuart Magoon, Director, Manchester Environmental Laboratory — Date

Approved by: — January 5, 2005
Cliff Kirchmer, Ecology Quality Assurance Officer — Date

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Abstract

Wide Hollow and Cowiche Creeks and Moxee Drain are on the Washington State 1998 303(d) list for impaired water quality due to fecal coliform (FC). Total Maximum Daily Load (TMDL) evaluations of these three streams are required by the federal Clean Water Act to reduce and eliminate sources of FC so that beneficial uses and state water quality criteria are met. The streams are located in or around the city of Yakima, a rapidly urbanizing area. Multiple potential sources of bacterial contamination are present, e.g. wildlife feeding and habitat areas; livestock on commercial and non-commercial farms; rural, residential, commercial, industrial, and urban stormwater runoff; on-site septic systems; and municipal wastewater treatment facilities. Irrigation and drainage systems complicate the hydrology and FC transport mechanisms in the area. Discharge permits held by multiple agencies and individual facilities complicate jurisdictional and source responsibility issues. This Quality Assurance (QA) Project Plan describes the goals, objectives, and work plan for the technical study portion of the TMDLs. The study will be conducted by the Washington State Department of Ecology (Ecology) Environmental Assessment Program in cooperation with the Ecology Water Quality Program, Yakima County, the City of Yakima, and the North Yakima Conservation District.

Introduction

Section 303(d) of the federal Clean Water Act periodically requires Washington State to prepare a list of all surface waters in the state that fall short of state surface water quality standards and are not expected to improve within the next two years. Wide Hollow and Cowiche Creeks and Moxee Drain are on the 1998 303(d) list for FC and several other pollutants. TMDL evaluations are required to identify the maximum amount of each pollutant to be allowed into these waterbodies so as not to impair beneficial uses of the water. The TMDL is then used to determine the wasteload allocations among sources with wastewater and stormwater permits, and load allocations among various nonpoint sources that do not have permits.

This QA Project Plan describes the technical study that will develop FC bacteria TMDLs in Moxee Drain, Cowiche and Wide Hollow Creeks, and their tributaries. These TMDLs will set water quality targets to meet FC bacteria standards, identify key reaches for source reduction, and allocate pollutant loads to point and nonpoint sources. The study will be conducted by Ecology Environmental Assessment Program in cooperation with the Ecology Water Quality Program at the Central Regional Office, Yakima County, the North Yakima Conservation District, and other local governments.

Background

Study Area

The Yakima urban area is located at the intersection of three Water Resource Inventory Areas (WRIAs) in Yakima County (Figure 1). The city of Yakima forms the urban center, with smaller nearby urban communities at Selah, Union Gap, Naches, Tieton, and Moxee City.

The area has been growing rapidly in the last ten years and has a unique checkerboard of industrial, urban, transportation, residential, orchard, irrigated agriculture, non-commercial farm, forest, and range land uses. The combined population in the city of Yakima, Union Gap, Tieton, and Moxee City increased by 20,000 people between 1990 and 2000 (OFM, 2002). The population increase has resulted in rapid conversions of farm, orchard, and range land into commercial, industrial, and residential areas. This trend is expected to continue.

Several streams, canals, and drains transect the urban area, carrying water to or from the Naches and Yakima Rivers and from creeks emanating from the surrounding foothills. Many were formerly used for irrigation and farmland drainage when the land use was dominated by agriculture. Now they provide water for agriculture but also for a broader range of sometimes conflicting uses like stormwater conveyance, fish habitat, and recreational opportunities.

The water quality characteristics of the streams, canals, and drains are influenced by the various uses of the water along with wastewater additions and runoff from adjacent land. The wastewater and runoff loads can add excessive FC bacteria, nutrients, oxygen-demanding substances, pesticides, and suspended sediment. Some reaches of these waterbodies have been monitored and have contaminant concentrations that do not meet state or federal water quality standards. These reaches have been included on the Washington State's 303(d) list.

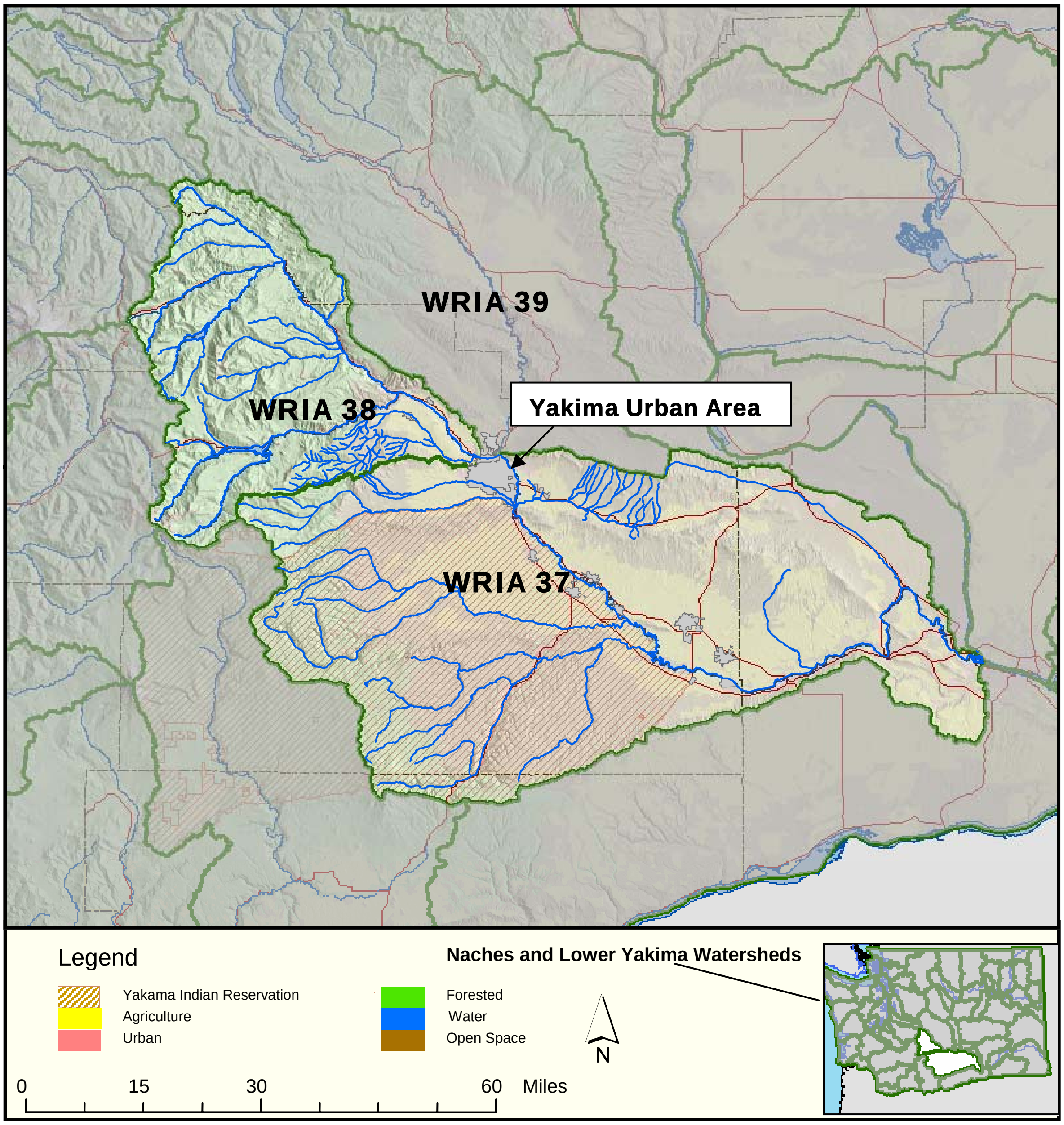


Figure 1. A Map of Watershed Resource Inventory Areas (WRIA) 37, 38, and 39 Showing the Yakima Urban Area and Surrounding Generalized Land Uses.

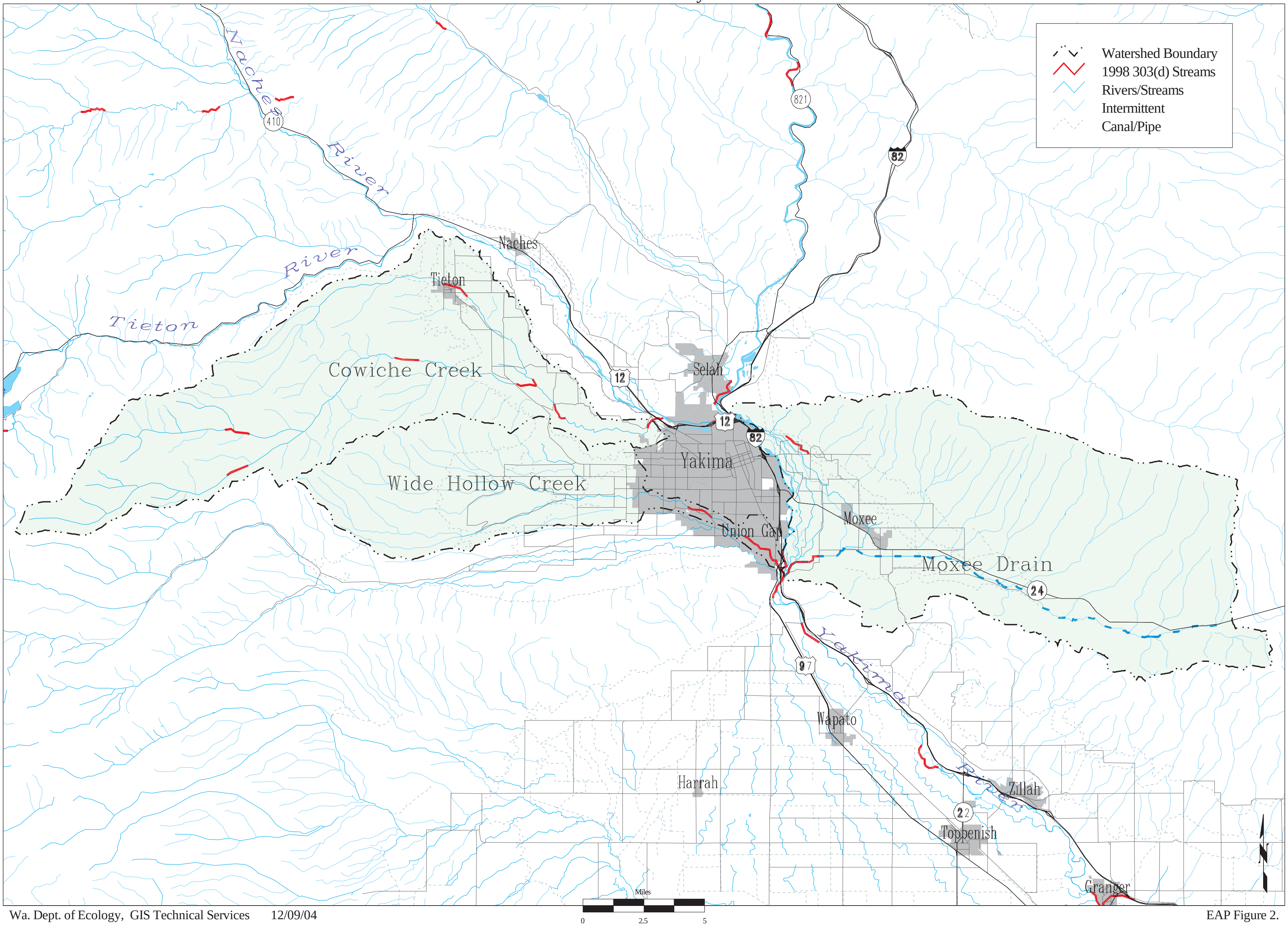
The Ecology Water Quality Program has determined that FC bacteria TMDLs are required for three creeks in the Yakima urban area: Cowiche Creek, Moxee Drain, and Wide Hollow Creek (Figure 2). Table 1 presents the 303(d) FC bacteria listings to be addressed in this study. The waterbodies also have 303(d) listings for temperature, fish habitat, instream flow, pesticides, and dissolved oxygen (DO). Only FC listings will be addressed by this study.

Table 1. Reaches of Cowiche Creek, Moxee Drain, and Wide Hollow Creek with Clean Water Act Section 303(d) Listings That Do Not Meet Fecal Coliform Standards and Will Be Addressed in the Present Study.

Waterbody	Old WBID No.	New ID	Township, Range, Section	303(d) List
Cowiche Creek	WA-38-1015	AR69RI	13N 17E 11	1998, 2002/4*
Cowiche Creek, N. Fork	WA-38-1016	TY98TL	13N 17E 3; 14N 17E 8	1996, 1998, 2002/4*
Cowiche Creek, S. Fork	WA-38-1017	VD04IL	13N 17E 3;14N 16E 35	1996, 1998, 2002/4*
Moxee Drain	WA-37-1048	YE21MH	12N 19E 8	1996, 1998
Wide Hollow Creek	WA-37-1047	DY38VO	12N 19E 6; 12N 19E 7 12N 19E 8; 13N 18E 27;13N 18E 35	1996, 1998, 2002/4*

* Proposed listing for 2002/2004.

Yakima Vicinity



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EAP Figure 2.

Figure 2. Map of the Study Area Showing the Location of Wide Hollow Creek, Cowiche Creek, and Moxee Drain in Relation to Major Cities, Highways, and Rivers.

Moxee Drain and Wide Hollow Creek are in the Lower Yakima River Basin (WRIA 37), and Cowiche Creek is in the Naches River Basin (WRIA 38). The study area lies within parts of the Eastern Cascade Slopes and Foothills Ecoregion, and the Columbia Basin Ecoregion. The Eastern Cascade Slope area of the Cowiche and Upper Wide Hollow watersheds get more rain and snow than the Yakima Valley and Moxee Watershed in the Columbia Basin Ecoregion (Figure 3a). Temperatures are cooler in the upper reaches of the Cowiche and Wide Hollow than the lower reaches (Figure 3b). Winter snow is common and increases with elevation.

All three have seasonal hydrologic characteristics and stream networks that are characteristic of agricultural irrigation or drainage operations, e.g. high summer irrigation flows and low winter natural base flows. All three streams flow through:

- Primarily privately-owned land.
- One or more urbanized areas (Figure 4) as defined by the US Census Bureau (Ecology, 2002).
- Ceded lands of the Yakima Treaty of 1855 where usual and accustom rights of the Yakama Indian Nation are retained.
- One or more irrigation and drainage districts.
- Areas where more than one public agency and industry have NPDES Phase II stormwater permit responsibilities.

Each of the three watersheds drain less than 150 square miles to the Yakima River but deliver more water than the watersheds generate naturally. During the irrigation season, the creeks carry interbasin returns transfered through the irrigation network, mainly from the Yakima, Naches, and Tieton Rivers. These return flows can be highly variable because they depend on water availability, the water needs of specific crops, and operational management of the irrigation network. The discharge volumes in Table 2 are most likely measured during the irrigation season. In comparison, Wide Hollow Creek instantaneous discharge volumes at Randall Park averaged 4.3 cfs from November through March in 2000, 2001, and 2002 (Ecology Station 37E120). At Cowiche Creek, monthly instantaneous measurements varied from 2.4 cfs in October 2001 to 128 cfs in April 2002 (Ecology Station 38G120 - Cowiche Creek at Zimmerman Road).

The Moxee Drain is a 136 square mile watershed in the Lower Yakima Basin (Figure 5). The Moxee Drain begins as an intermittent natural stream in the Upper Moxee Valley between the Yakima Ridge and Rattlesnake Hills. Most of the upper watershed is rangeland, parts of which are in the Yakima Training Center. The open drain parallels State Highway 24 down the valley. Agricultural uses predominate as irrigation water is available from several canals routing water from the Yakima River into the watershed.

Water from the Roza, Union Gap, Moxee, Hubbard, and Selah-Moxee Canals influence the quantity and quality of water in the Moxee Drain. Many of the canals cross by way of under-drains, but others have direct or indirect inputs into Moxee Drain. Irrigated fields using water from the canals discharge tail water into the laterals or directly into Moxee Drain. Spill and overflow water from canal operations may also enter laterals or directly into Moxee Drain.

Moxee City (population 820) lies north of the drain. The wastewater treatment plant (WWTP) discharges to one of many lateral drains to the lower reaches of Moxee Drain. Residential developments and non-commercial farms have been established in recent years in the unincorporated county around Moxee City. The urban/residential use comprises approximately 2% of the watershed area (YVCOG, 1995). The U.S. Bureau of Reclamation operates a continuous stream gaging station at Birchfield Road (BICW). The Moxee Drain enters the Yakima River at river mile 107.3.

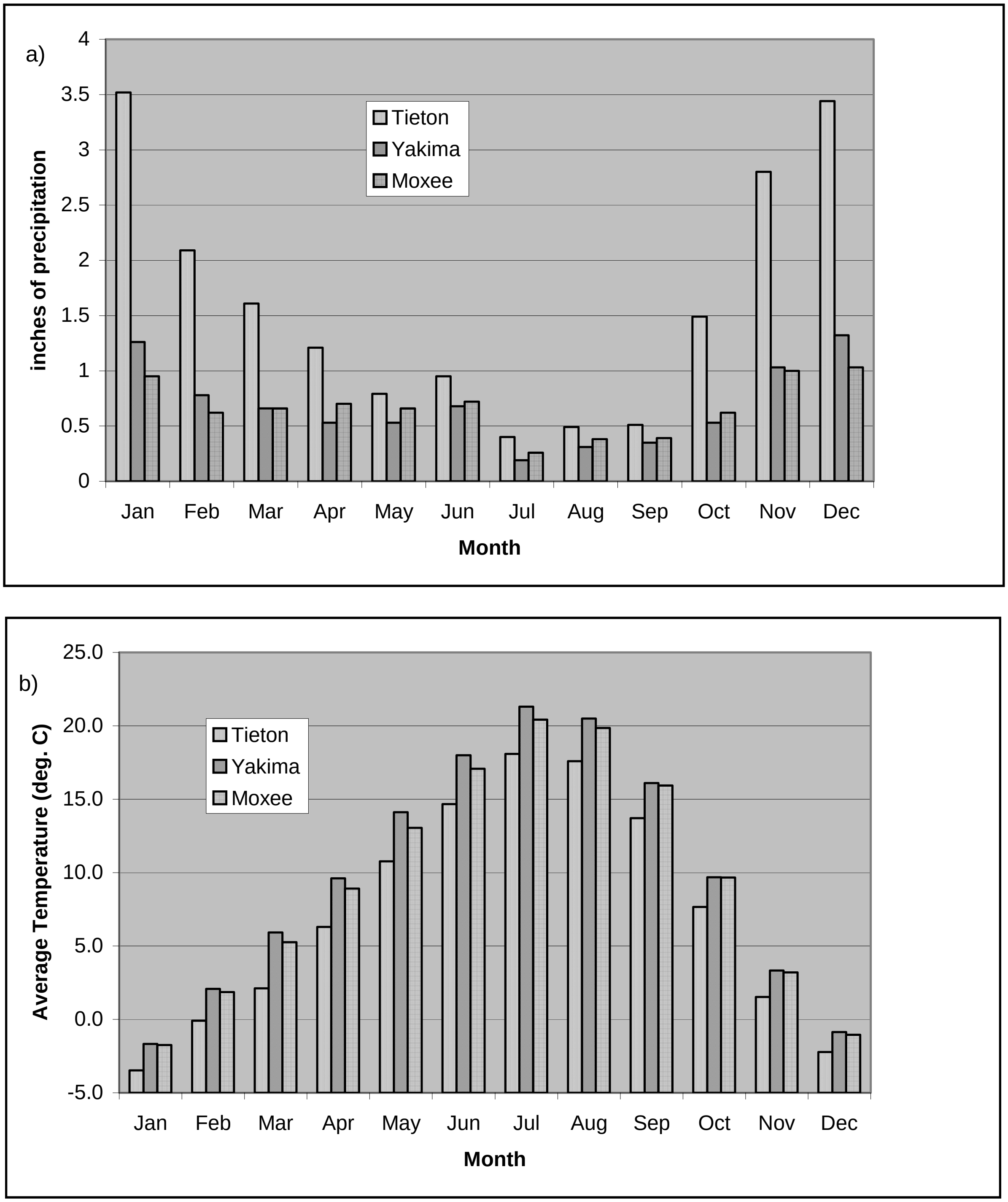


Figure 3. a) Monthly Average Precipitation at Weather Stations Located at Tieton Intake, Yakima Airport, and 10 Miles East of Moxee City. b) Average Monthly Temperatures for the Same Stations.

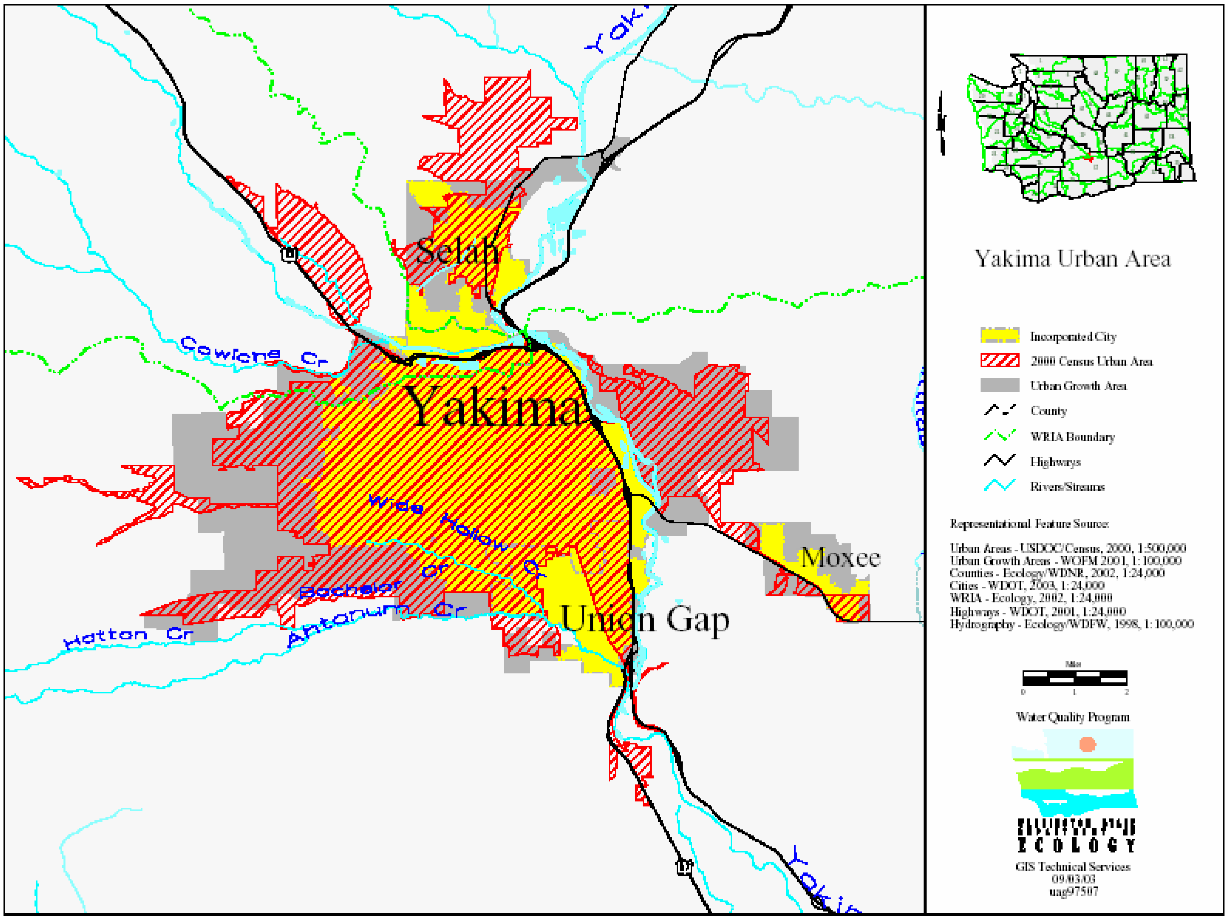


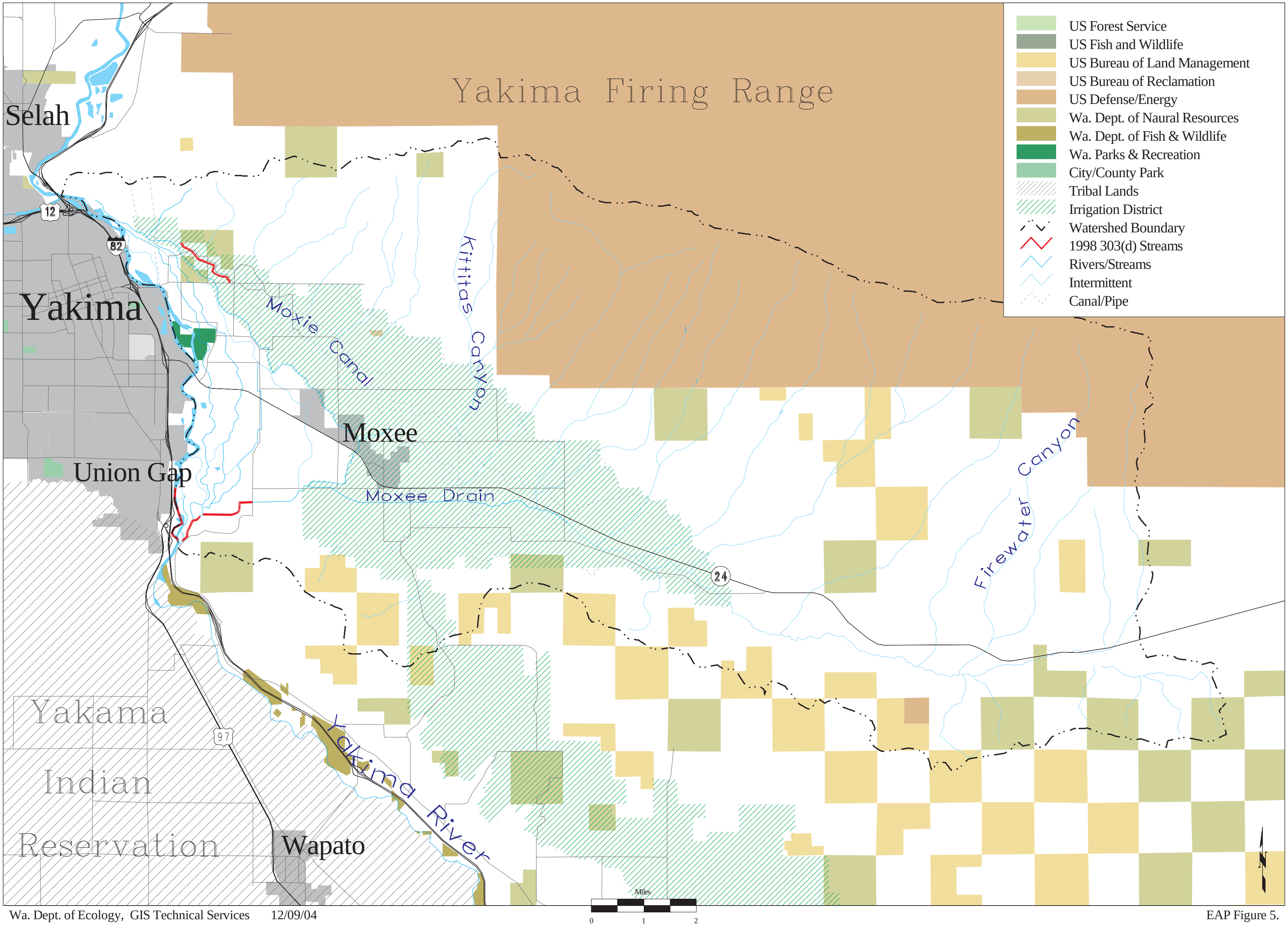
Figure 4. A Map of the Yakima Urban Area and Urban Growth Areas for Municipalities in the Cowiche and Wide Hollow Creeks and Moxee Drain Watersheds (Ecology, 2003).

Table 2. Basic Characteristics of Moxee Drain, Wide Hollow Creek, and Cowiche Creek. Median Discharge Estimates for Moxee and Wide Hollow at Union Gap Based on Instantaneous Discharge Data Collected from 1974 to 1981 (Rinella, McKenzie, and Fuhrer, 1992). The Cowiche Creek Median Flow is Based on 24 Monthly Measurements Taken October 2000 to September 2002 (Ecology, 2004).

Stream Name	Total Length	Drainage Area	Gage Location	Median Discharge
	(miles)	(miles^2)		(cfs)
Moxee Drain	20	136	Birchfield Road (RM 1.7)	35
Wide Hollow Creek	21.7	64.8	Union Gap (RM 0.9)	25
Wide Hollow Creek	-	-	Randall Park (RM 7.2)	15
Mainstem Cowiche Creek	7.5	120*	Zimmerman Road (RM 6.4)	14
South Fork Cowiche Creek	25.2	71.5		-
North Fork Cowiche Creek	19.1	39.9		-

* Includes the drainage areas of the North and South Forks.

Moxie Drain Watershed



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EAP Figure 5.

Figure 5. Map of the Moxee Drain Watershed Showing Major Public Land Owners, Irrigation Districts, and the Location of Facilities Holding Waste or Other Types of Permits with Ecology.

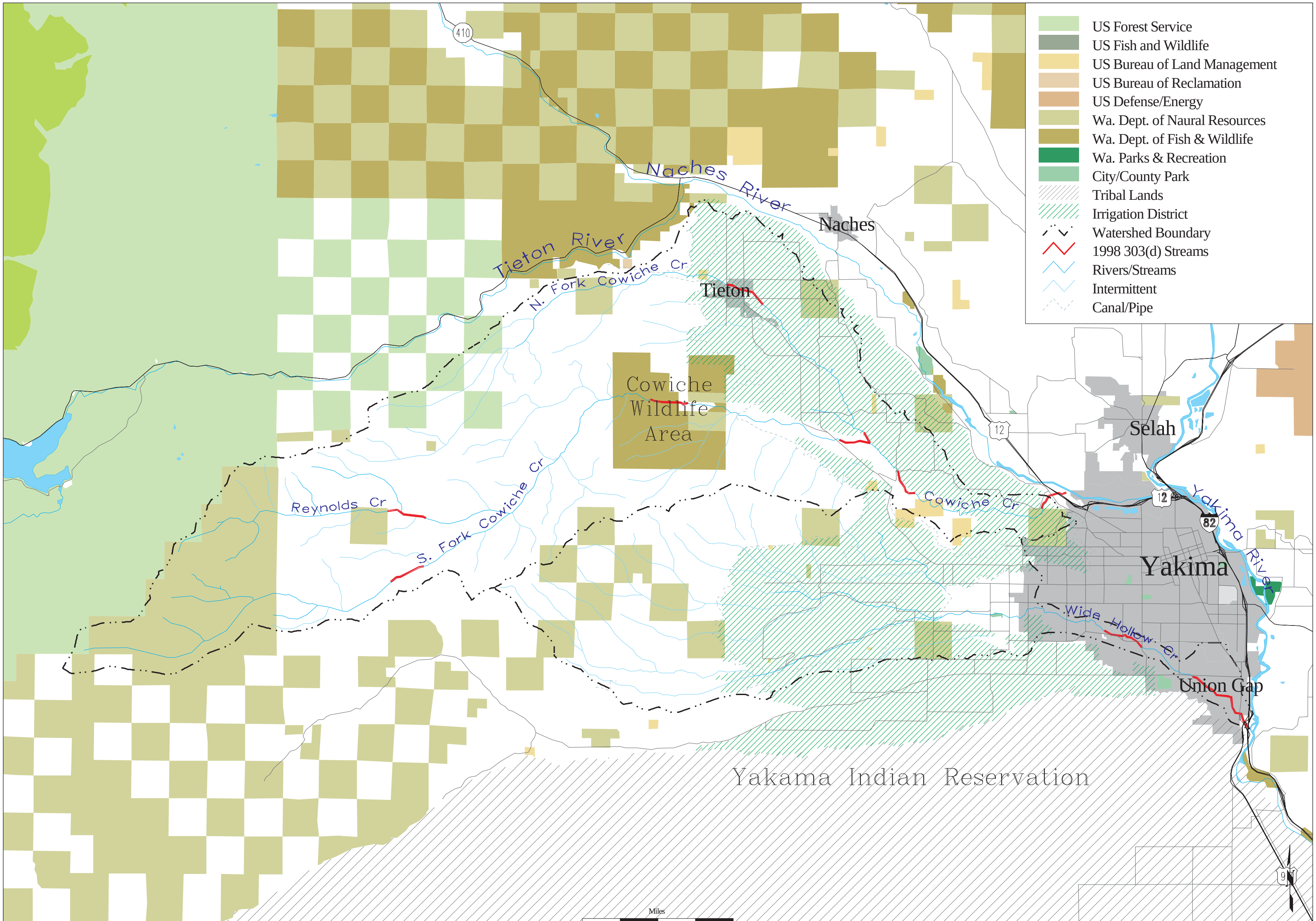
Wide Hollow Creek drains 65 square miles south and east of Yakima (Figure 6). The creek begins in Cowiche Mountain near Oak Spring. The upper watershed is mainly rangeland, some of which is managed by the Washington Department of Natural Resources. The transition to pasture, orchards, and cropland occurs in the valley bottom where irrigation canals convey water from the Naches and Tieton Rivers. The underlying groundwater is part of the greater Ahtanum Valley that includes areas to the south and east under Ahtanum Creek (Sinclair, 2003).

The West Valley area, downstream of where Cottonwood Creek meets Wide Hollow Creek and the Congdon Canal, is experiencing rapid urbanization from Yakima. The Wide Hollow Creek Watershed has the largest percentage of urban land use (28%) of the three creeks in the study area (YVCOG, 1995). Several return drains, diversions from drainage and irrigation districts, and smaller spring-fed tributaries also are present in the lower portions of the valley. Wide Hollow Creek continues to be bordered by orchard; livestock pasture; and residential, commercial, and light industrial land usage all the way to Union Gap (population 5,621). At one time treated wastewater from Union Gap was discharged into Wide Hollow Creek, but for the past 30 years it has been sent to the Yakima WWTP. Wide Hollow Creek enters the Yakima River at river mile 107.4 after crossing under Interstate 82 and being joined by East Spring Creek from the north.

Cowiche Creek drains approximately 120 square miles north and east of Yakima in the Naches Basin (Figure 6). The watershed is separated from the Naches River by Naches Heights along the northeast and from the Tieton River by Divide Ridge to the northwest. Wide Hollow Creek and Ahtanum Creek are separated from the South Fork of Cowiche Creek by Cowiche Mountain to the south.

The Upper South Fork and North Fork areas of the watershed are forested. The middle part of the South Fork is bounded by rangeland, and the Lower South Fork and North Fork through the mainstem is primarily surrounded with agricultural uses. Orchard fruit and forage crops are grown in the areas served by the Yakima-Tieton Irrigation District.

Cowiche - Wide Hollow Creek Watershed



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EAP Figure 6.

Figure 6. Map of the Cowiche Creek and Wide Hollow Creek Watersheds Showing Major Public Land Owners, Irrigation Districts, and the Location of Facilities Holding Wastewater or Other Types of Permits with Ecology.

The upper branches of the Cowiche begin in national and state forestlands. Other public lands are found downstream. For example, the Cowiche Wildlife Area occupies 4,526 acres along the South Fork Cowiche Creek from RM 4.2 to RM 7.7 (Figure 6). The area provides the Cowiche elk sub-herd with habitat for winter range. Also, Cowiche Canyon Conservancy occupies three miles on an abandoned railroad grade along the Mainstem Cowiche Creek from RM 2.8 to RM 5.8.

The developed areas around Tieton (population 1,154), Cowiche (unincorporated), and near the mouth at the city of Yakima's northwestern boundary constitute only 6% of the watershed area. The Tieton WWTP had a lagoon system that discharged to the North Fork Cowiche Creek at RM 4.9. Cowiche had a wastewater treatment plant that discharged to the North Fork at RM 2.0. These two systems were consolidated into one regional facility in 2002. It discharges to the North Fork at RM 2.0. Several fruit packing plants also are located in the Tieton/Cowiche area.

The two forks join at RM 7.5 below Cowiche and enter the Cowiche Canyon one mile downstream of the confluence. The canyon begins fairly narrow and sparsely populated, but in the last few miles opens into a wider valley that allows more room for homes and small orchards. A small commercial area is located just before the creek crosses under Highway 12 and enters the Naches River at river mile 2.8.

Water Quality Standards and Beneficial Uses

The Washington State Water Quality Standards, set forth in Chapter 173-201A of the Washington Administrative Code, include designated beneficial uses, waterbody classifications, and numeric and narrative water quality criteria for surface waters of the state.

Moxee Drain and Wide Hollow Creeks discharge directly to the Yakima River. Cowiche Creek discharges to the Naches River just upstream of its confluence with the Mainstem Yakima River. Moxee Drain and Wide Hollow Creek are Class A waterbodies. Cowiche Creek is also a Class A waterbody except for an area in the Upper North Fork. The North Fork Cowiche Creek enters a 'checkerboard' section of the Wenatchee National Forest at approximately river mile 12.5 (Figure 6). From that point upstream to its headwaters, the North Fork Cowiche Creek is considered a Class AA waterbody based on Chapter 173-201A-120(1)(6) WAC.

Characteristic uses for both Class AA and Class A waterbodies include water supply (domestic, industrial, agricultural), stock watering, fish and shellfish (salmonid and other fish migration, rearing, spawning, and harvesting), wildlife habitat, recreation (primary contact recreation, sport fishing, boating, aesthetic enjoyment), and commerce and navigation.

Numeric criteria for specific water quality parameters are intended to protect designated uses. However, criteria are more stringent in AA waters such that the water shall markedly and uniformly exceed the requirements for all, or substantially all, uses. Ecology revised the state water quality standards in July 2003, although the revisions have not been evaluated and approved by EPA to date. Until the new standards are approved, the previous version remains in effect for TMDLs and other programs administered under the federal Clean Water Act. Under the revised water quality standards, while the waterbody classification system will change, the

FC bacteria numeric target for each of the waterbodies included in the present study will not. Current freshwater standards are listed below for bacteria. Proposed new standards can be found on the Ecology website: http://www.ecy.wa.gov/programs/wq/swqs/index.html.

Fecal Coliform Bacteria

- For Class A Waters: "*…fecal coliform organism levels shall both not exceed a geometric mean[1] value of 100 colonies/100mL, and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 200 colonies/100 mL.*"

- For Class AA Waters: "*…fecal coliform organism levels shall both not exceed a geometric mean value of 50 colonies/100 mL and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 100 colonies/100 mL.*"

The FC criteria have two statistical components, a geometric mean and an upper limit value that 10 percent of the samples cannot exceed. Fecal coliform samples collected randomly, or under a stratified sampling design from most sites, follow a lognormal distribution. In Washington State FC TMDL studies, the upper limit statistic (e.g. not more than 10% of the samples shall exceed) has been interpreted as a 90^{th} percentile value of the lognormalized values (Cusimano, 1997; Joy, 2000; Sargeant, 2002).

The 90^{th} percentile statistic uses the variability of FC counts and the number of samples collected at a site in the upper limit criterion estimate. TMDL targets based on the calculated 90^{th} percentile criterion are usually more stringent, rarely are they lower than the 10% upper limit. In this way, the 90^{th} percentile values provide a margin of safety in protecting beneficial uses. In addition, the statistical treatment of the data allows us to use the statistical rollback method (Ott, 1995) approach to setting FC target counts--since loading limits to comply with FC criteria are not useful.

Reaches of the three creeks in the study area are available to the public for primary and secondary recreation. None of the three have recorded public drinking water system intakes (Yakima Health District, 2004). Since there are no public bathing beaches on any of the three creeks, only informal swimming occurs--most likely in July, August, and early September. Game fishing is allowed in Cowiche Creek and Wide Hollow Creek from June 1 to October 31 (http://wdfw.wa.gov/fish/regs/2004/2004sportregs.pdf). Hunters, hikers, agricultural workers, and adventurous children may have occasional contact with the water from these creeks.

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[1] The geometric mean is calculated as the n^{th} root of the product of n numbers.

Potential Sources of Bacteria

Wastewater and Stormwater Discharge Permits

Fecal coliform bacteria can be present in a wide variety of municipal and industrial wastewater and stormwater sources. Most municipal WWTPs have disinfection processes to treat discharged effluent using chlorine, ultraviolet, or ozone. For example, Moxee City and the Cowiche Regional WWTPs treat their effluent with ultraviolet (UV) light. Industrial and stormwater sources are less likely to disinfect directly, but they can use filtration, settling, and other practices to reduce bacteria concentrations.

No method is 100 percent effective at removing FC all of the time, so FC bacteria can enter the receiving waters from these sources. Fecal coliform bacteria and other potential contaminants from industrial and municipal sources are regulated by various National Pollution Discharge Elimination System (NPDES) and general permits from Ecology.

Two municipal WWTPs are located in the study area: Moxee City WWTP and the Cowiche Regional WWTP (Table 3). Both have been through recent system upgrades that have improved effluent quality. The two plants also have somewhat complicated effluent discharge situations.

Moxee City WWTP is an oxidation ditch with secondary clarification and UV disinfection. Effluent from the plant discharges to a lateral drain of Drainage Improvement District (DID) #11 that joins Moxee Drain within 0.5 miles. The weekly geometric mean FC limit is 200 cfu/100 mL, and the monthly geometric mean limit is 100 cfu/100 mL. The limits are more stringent than in a conventional permit because the effluent outfall site has no mixing zone. Background FC counts in the DID drain are not known.

The Regional Wastewater Treatment Plant at Cowiche serves the communities of Tieton and Cowiche. The plant consists of an activated sludge sequencing batch reactor (SBR) plant operated in the extended aeration mode, constructed wetlands, and UV disinfection. During the spring, summer, and autumn, the free surface-type constructed wetlands provide effluent polishing and nutrient uptake to wastewater after treatment in the SBR aeration basins. Partially treated wastewater from either the wetlands or the reaeration/equalization basin is passed through an effluent filter. After filtration, effluent is disinfected in a two-bank UV system. The weekly geometric mean FC limit is 100 cfu/100 mL, and the monthly geometric mean limit is 50 cfu/100 mL.

Effluent is then discharged to a 500-foot long cooling channel where it is joined by subsurface water intercepted by curtain drains around the facility and by non-contact cooling water from a local fresh fruit packer. The cooling channel is planted with vegetation and meanders through a lagoon from the old WWTP system. The effluent enters the North Fork Cowiche Creek at about RM 2.

Several fresh fruit packing plants and warehouses are located in the study area. Many of these have a NPDES wastewater discharge general permit (Table 3). The permit authorizes treatment and disposal methods for wastewater, cooling water, stormwater, and solid waste. FC bacteria limits are not included in these permits, but they will be added if elevated counts in the wastewater or stormwater discharge are found. Elevated FC counts would not necessarily be expected in stormwater from fresh fruit packing warehouses. However, stormwater from industrial and commercial properties often can have surprisingly high FC counts from such diverse sources as misconnected sanitary lines to roosting birds on roofs (Schueler, 1999).

Two facilities on Wide Hollow Creek have individual industrial NPDES stormwater permits. The Del Monte plant discharges stormwater to the city of Yakima stormwater system. The stormwater drain discharges to Wide Hollow Creek 2.5 miles to the south. Western Recreational Vehicles has three stormwater discharges to Wide Hollow Creek near RM 6.2.

Yakima, Union Gap, and urbanized portions of Yakima County qualify as NPDES Phase II municipal separate storm sewer systems (MS4) permit candidates. Figure 4 shows the urban areas determined by the 2000 Census that must be covered under the NPDES Phase II stormwater permits. Washington Department of Transportation (WSDOT) highways and facilities are also required to be covered under a MS4 permit. WSDOT controls the major roads and highways through the urbanized areas, e.g. U.S. Highways 97 and U.S. Highway 12, Interstate 82, and State Route 24. There is also a WSDOT Road Maintenance Facility at Union Gap on Spring Creek, a tributary to Wide Hollow Creek.

Table 3. A List of NPDES and State General Wastewater or Stormwater Permit Holders in the Yakima Tributaries Study Area. Fruit = NPDES Wastewater Discharge General Permit for Fresh Fruit Packing; Municipal = NPDES Municipal Wastewater Discharge Permit; Industrial SW = Industrial Stormwater Permit; Phase II SW = Future Municipal NPDES Stormwater Permit.

Permit Holder	Receiving Water	Permit Number	Permit Type
Clasen Fruit & Cold Storage	Wide Hollow Creek	WAG435176B	Fruit
Borton & Sons	Wide Hollow Cr. Via Lateral T	WAG435131B	Fruit
Eakin Fruit Company	Wide Hollow Cr. Via Stormwater Pipe	WAG435031B	Fruit
Ackley Fruit Company	Cowiche Creek	WAG435070B	Fruit
Lloyd Garretson Co.	Cowiche Creek		Fruit
Cowiche Growers, Inc.	North Fork Cowiche Creek	WAG435046B	Fruit
Strand Apples	North Fork Cowiche Creek	WAG435144B	Fruit
Strand Apples	North Fork Cowiche Creek Via Unnamed County Ditch	WAG435036B	Fruit
Roy Farms, Inc.	Moxee Drain Via Roza Drain Ditch	WAG435221B	Fruit
City of Moxee	Lateral to Moxee Drain	WA0022501C	Municipal
Cowiche and Tieton	North Fork Cowiche Creek	WA0052396A	Municipal
Del Monte Foods 125	Wide Hollow Creek	SO3000215D	Industrial SW
Western Recreational Vehicles	Wide Hollow Creek	SO3004527B	Industrial SW
Far West Fabricators	Moxee Drain via Drain	SO3001307D	Industrial SW
Yakima County	All creeks and drains in urbanized areas		Phase II SW
City of Yakima	Wide Hollow Creek		Phase II SW
Washington Dept. of Transportation	Wide Hollow Creek Cowiche Creek Moxee Drain		Phase II SW

One dairy is located near the head of the Moxee Drain. The DeVires Family Farm has a certified Dairy Nutrient Management Plan for wastes generated by approximately 2700 cows. Manure and other wastes are not allowed to enter the creek from the dairy facility.

Wildlife and Background Sources

All three creeks have areas where wildlife can contribute background loads of FC bacteria. Elk, deer, beaver, muskrat and other wildlife in headwater and rural valley areas are potential sources of FC bacteria. Bridge structures can attract large numbers of nesting birds whose droppings fall in the water. Open fields are attractive feeding area for some birds whose presence can increase FC counts in runoff.

Usually these sources are dispersed and do not elevate FC counts over state criteria. Sometimes animals are locally concentrated and can cause elevated counts. The winter elk feeding at Cowiche Wildlife Area is one area that will be monitored on the South Fork Cowiche Creek for concentrated animal population effects. Ducks and geese at Randall Park along Wide Hollow Creek were noted as a potential FC source by Kendra (1988). Fecal coliform loading from the park area will be monitored. Seasonal bird-nesting under bridges will be evaluated in field notes, and FC sampling results in the creeks will be compared to their presence and absence.

Nonpoint Sources

Nonpoint sources and practices are dispersed and not readily controlled by discharge permits. Several types of potential nonpoint sources are present in the study area. Range and pastured livestock with direct access to drainages can be a source of FC contamination. Poor livestock or pet manure management on non-commercial farms is another source. Poorly constructed or maintained on–site septic systems are also potential sources in each of the watersheds.

Fecal coliform bacteria from nonpoint sources are transported to the creeks by direct and indirect means. Often livestock have direct access to water. Manure is deposited in the riparian area of the access points where fluctuating water levels, surface runoff, or constant trampling can bring the manure into the water. Some residences may have wastewater piped directly to waterways or may have malfunctioning on-site septic systems where effluent seeps to nearby waterways. Swales, sub-surface drains, and flooding through pastures and near homes can carry FC bacteria from sources to waterways.

Historical Data Review

Water quality sampling performed by the United States Geological Survey (USGS) in 1988 (Embrey, 1992) documented numerous violations of water quality bacteria standards in Moxee Drain and Wide Hollow Creek, resulting in their inclusion on Washington's 303(d) list of impaired waters. Additional data collected in Wide Hollow Creek by Ecology's Environmental Assessment (EA) Program in 1987 (Kendra, 1988) and 2001-2002 (Ecology, 2004) documented further violations of FC bacteria standards. Data collected in 1995 by the Yakama Indian Nation (Palmer, 1996) documented violations of water quality bacteria standards in Cowiche Creek. Ecology found additional evidence of elevated FC bacteria at one site in Cowiche Creek in 2001-2002 (Ecology, 2004).

Washington State Department of Ecology

Ecology collected ambient monitoring data at locations listed in Table 4 below. These stations are not included in the statewide long-term monitoring network. Recent ambient monitoring records from two sites contain several FC bacteria counts that indicate non-compliance with water quality standards (Figures 7 and 8). FC counts and loads in Cowiche and Wide Hollow Creeks show a season cycle--counts and loads are higher in the months of May through October. FC counts at the Wide Hollow Creek site were usually greater than 200 cfu/100 mL throughout the year whereas FC counts at the Cowiche Creek site were usually lower than 200 cfu/100 mL. Summary statistics for the two sites are shown in Table 5.

Table 4: Historical Ecology Ambient Monitoring Stations in the Load Study Area.

Station ID	Station Name	Period of Record
37E070	Wide Hollow Cr at Union Gap	1971, 1974, 1992
37E090	Wide Hollow Cr at Goodman	1941, 1971, 1974
37E120	Wide Hollow Cr at Randall Park	2001, 2002
38G120	Cowiche Cr at Zimmerman Rd	2001, 2002

Table 5. Summary Fecal Coliform Statistics for Cowiche Creek (38G120) and Wide Hollow Creek (39E120) Data Collected by Ecology from October 2000 to September 2002. All Values cfu/100 mL. Washington State Class A freshwater Criteria are Also Shown. n = Number of Samples.

		Cowiche Creek			**Wide Hollow Creek**		
Season	**n**	**GM**	**90th %tile**	**Range**	**GM**	**90th %tile**	**Range**
Annual	24	137	1776	4 – 3800	491	2949	27 – 17,000
Nov. – Apr.	12	27	100	4 – 110	334	1853	27 – 4500
May – Oct.	12	689	3544	87 – 3800	724	4374	110 – 17,000
WA State Criterion		100	200		100	200	

A more in-depth study of Wide Hollow Creek was performed by the Water Quality Investigations Section in 1987 (Kendra, 1988). The study examined water, sediment, and biota in the creek in an effort to characterize water quality under low flow conditions, and to relate changes in water quality, sediment, and biota to point and nonpoint source effects. Water sampling took place over a two-day period in July for the following parameters: temperature, pH, dissolved oxygen, flow, turbidity, chemical oxygen demand, nutrients, FC, enterococci, hardness, and metals. Kendra noted that FC bacteria levels increased downstream, likely as the result of cumulative effects of streamside livestock pasturing, possibly contaminated pipes discharging in lower reaches, and septic system failures. He also implicated excessive waterfowl populations at Randall Park as a potential bacteria source. Two sites with particularly high bacterial levels were at the mouth of an unnamed tributary at Union Gap, and a pipe effluent at 48th Avenue.

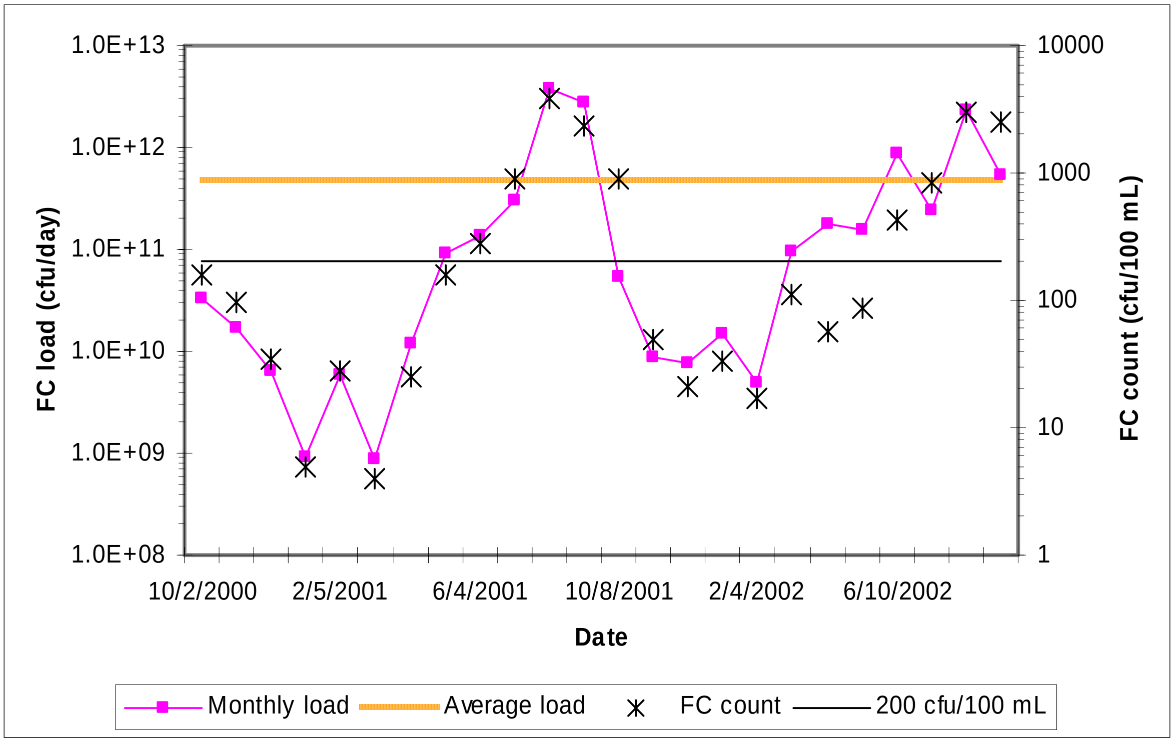

Figure 7. Cowiche Creek Fecal Coliform (FC) Data Collected at Ecology Site 38G120 at Zimmerman Road from October 2000 to September 2002. The 200 cfu/100 mL State Criterion and the Annual Average FC Load are Also Shown.

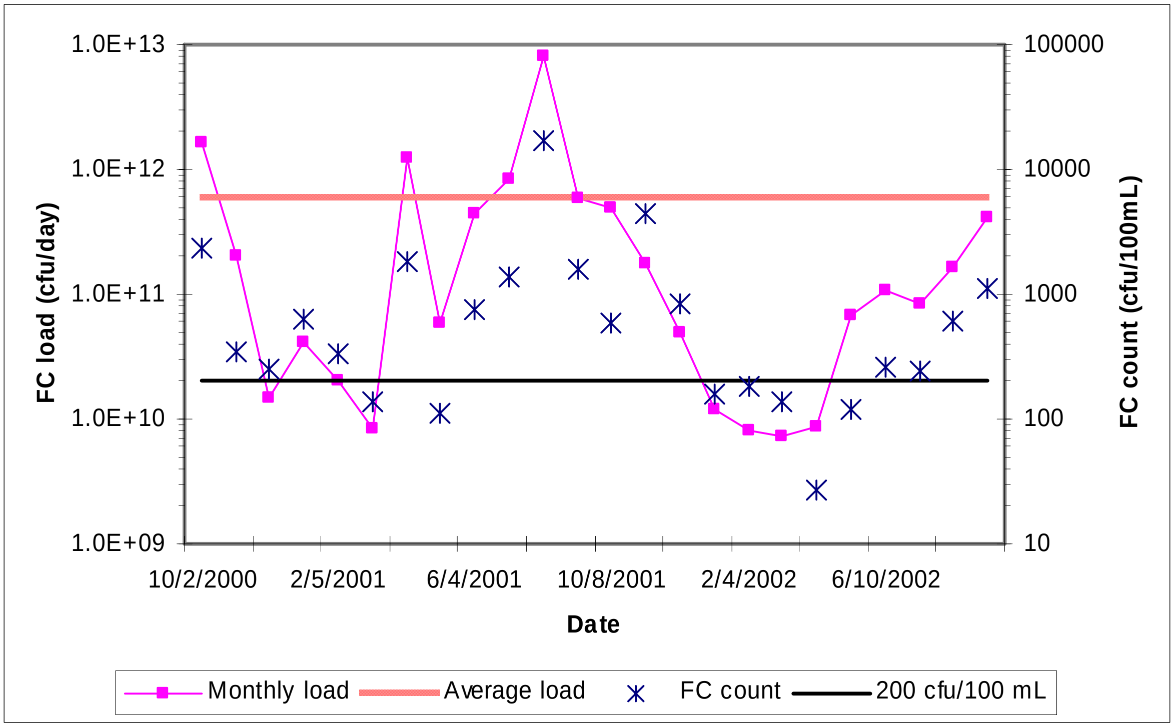

Figure 8. Wide Hollow Creek Fecal Coliform (FC) Data Collected at Ecology Site 39E120 at Randall Park from October 2000 to September 2002. The 200 cfu/100 mL State Criterion and the Annual Average FC Load are Also Shown.

Yakama Indian Nation

The Yakama Indian Nation Natural Resource Division sampled five sites in the Cowiche Creek watershed from January through November in 1995 (Palmer, 1996). The FC bacteria results are summarized in Table 6. The data from most sites followed the pattern noticed at other sites in the study area, i.e. higher FC counts occur in May through October than from November through April.

The data collected at the Cowiche Wildlife Area on the South Fork Cowiche Creek met Washington State FC criteria on a seasonal and annual basis (Table 6). However, this area was placed on the 303(d) list in 1996 because five samples collected in July through August had a mean count of 104 cfu/100 mL which would not meet the 100 cfu/100 mL Class A geometric mean criterion. The geometric mean count of these five samples was 91 cfu/100 mL, which does meet the criterion. Since the geometric mean value is within 10% of the criterion, further sampling should be conducted to confirm its current water quality condition.

The data collected on the North Fork Cowiche Creek near Tieton had only one FC count over 200 cfu/100 mL of the 16 samples collected (6%). Probably because of the single sample with 900 cfu/100 mL, the data set was placed on the 303(d) list in 1996; however, the site should not have qualified for the 1998 303(d) list. The values listed in Table 6 are statistical 90th percentiles that reflect the variability in the data set.

Table 6. A Statistical Summary of 16 to 18 Fecal Coliform Results Collected at Five Sites by the Yakama Indian Nation from January to November in 1995. All Values are cfu/100 mL; GM = Geometric Mean; 90^{th} = 90^{th} Percentile Value; * = Values are Estimates Because Some Counts Were Estimated as >1600 cfu/100 mL.

	North Fork Cowiche Creek				South Fork Cowiche Creek				Cowiche Creek	
	Near Tieton		Near Mouth		Cowiche Wildlife Area		Near Mouth		Mainstem in Canyon	
	GM	90^{th}	GM*	90^{th*}	GM	90^{th}	GM*	90^{th*}	GM*	90^{th*}
Annual	58	369	238	1355	28	158	107	973	240	2062
Nov. – May 15	25	374	72	176	10	42	38	187	58	361
May 16 – Oct.	96	181	621	1956	64	124	246	1983	747	1879
# of Samples	16		18		18		18		18	
Criterion	100	200	100	200	100	200	100	200	100	200

U.S. Geological Survey

In 1992, the USGS chose the Yakima River as a pilot basin in a newly formed program for a National Water Quality Assessment (NAWQA) Program. The program would describe water quality for the nation's water resources; define long-term trends in water quality; and identify, describe, and explain the major factors affecting water quality (Embrey, 1992). Monthly sample collection at seven fixed stations and eight synoptic sampling events were undertaken. Dissolved oxygen, trace elements, nutrients, suspended sediment, trace organic chemicals, biology, and fecal-indicator bacteria were monitored. Bacteria samples collected on Wide Hollow Creek and Moxee Drain all exceeded 1000 colony forming units per 100 mL (cfu/100 mL) for those sites (Table 7). This report resulted in several of the bacteria 303(d) listings in 1996 that will be addressed by the TMDL.

A continuation of the NAWQA Program in the Yakima River Watershed was conducted in 1999 and 2000 (Morace and McKenzie, 2002). Mainstem Yakima River sites and tributaries were sampled in August of 1999, and small and intermediate sized agricultural watersheds were sampled in July and October/November of 2000. Several sites in the Moxee Drain Watershed and one site on Wide Hollow Creek were sampled for FC bacteria (Table 7). The 1999 and 2000 sampling indicated that the Moxee and Wide Hollow sites continued to have elevated FC counts during the irrigation season. Samples collected at the 'Drain near Postma Road' suggested that FC counts can be highly variable at small drains (Table 7).

Table 7. USGS Fecal Coliform Bacteria Sample Results Collected from the Moxee and Wide Hollow Watersheds During Four Synoptic Surveys on the Yakima River Between 1988 and 2000 (Embrey, 1992; Morace and McKenzie, 2002). All Values As cfu/100 mL. The Number of Samples is in Parenthesis Following Fecal Coliform Count Range.

Site	1988 (July)	1999 (August)	2000 (July)	2000 (Oct-Nov)
Moxee Drain at Birchfield Road	1,100 – 1,800 (4)	2,900	580	120
Moxee Drain at Beane Road			> 960	23 J
Roza Canal at Beane Road			34	
319 BMP site near Walters Road	590		96	23
Selah-Moxee Canal at Duffield Road			> 40	
Drain near Postma Road			1,500	53
Drain near Postma Road*			8 – 1,500 (5)	11– 53 (4)
Wide Hollow Creek at Union Gap	1,100 – 2,100 (2)	600		

*Short-term variability site – samples collected over two or consecutive three days.

North Yakima Conservation District

The North Yakima Conservation District has collected flow, temperature, conductivity, dissolved oxygen (DO), pH, turbidity, and total suspended solids (TSS) data in the Moxee Drain Watershed since 1989 (North Yakima Conservation District, 1993; 2003). Turbidity temperature, conductivity, pH, and DO were also collected at sites in the Cowiche Creek and Wide Hollow Creek Watersheds from 2000 to 2002 (North Yakima Conservation District, 2003). FC bacteria samples were not collected.

Yakima County

Yakima County Public Works collected samples from 31 sites in the Yakima area between February and November 2003 (Yakima County, unpublished data). Samples were collected from Moxee Drain, Cowiche Creek, and from outfalls into Wide Hollow Creek. Total coliform and E. coli were among the analyses made (Table 8). The E. coli data were quite variable, seasonally and between sampling sites.

Yakima County Public Works has joined with the cities of Yakima and Union Gap to begin designing a regular network of stations to monitor surface water quality and the impacts of stormwater to meet their NPDES Phase II stormwater permit obligations (Yakima County, 2004). In addition, groundwater and surface water protection plans are being developed and implemented. Yakima County staff members have provided valuable information about the hydrology of the study area, and they are interested in providing additional help as resources become available.

Yakima County Health District holds records and geographic information system (GIS) data on the location, age, and condition of water systems and on-site sewage treatment systems, e.g. individual septic tanks, community systems, and small community wells. These sources can be examined for project planning and data interpretation purposes.

Table 8. E. coli Counts Reported by the Yakima County Public Works Department in Samples Collected Between February and November 2003. Counts are Most Probable Number (MPN).

Site Name	Site Description	ID	1st QT	3rd QT	4th QT
WHC-upstream	West Valley park-off 80th	SP 7	1	>200	53
Cowiche Creek-mouth	Dirt rd off SR12 past 40th Ave.	SP 8	-	>200	4
DID 38 outfall into WHC	NW corner of bridge on 64th Ave.	SP 10	1	83	1990
DID 48 outfall into WHC	NW corner of bridge on 64th Ave.	SP 11	-	70	-
DID 48 outfall into ditch	SW of 48th Ave. & Nob Hill Blvd.	SP 12	<1	>200	166
DID 40 outfall into WHC	SE corner of Logan & 38th Ave.	SP 14	2.2	>200	1200
Tieton Canal	Wide Hollow and 96th Ave.	SP 15	-	>200	6.3
DID 4 by outfall into WHC	MH-3 in Gardner Nursery.	SP 16	2400	>200	>2420
Shaw Creek	80th & Wide Hollow Rd.	SP 17	-	-	68.3
DID 24 outfall L2 into WHC	MH16- N. of Pioneer,W. of Cornell.	SP 20	220	345	5
DID 24 outfall L1 into WHC	MH1-on 3rd Ave. N of Ahtanum Rd.	SP 21	>2400	1	<1
WHC-downstream	N side of off ramp I-82 to Union Gap	SP 22	-	272	47
Moxee Drain	Thorp Rd	SP 26	60	222	93
Spring Creek East	Freeway Ave. in Union Gap MHp	SP 29	140	86	152
Union Gap Ditch	Old mill Main St. in Union Gap.	SP 31	-	411	260

DID = drainage improvement district.

Project Description

Project Goals and Objectives

The goal of the project is to establish FC bacteria TMDLs for Cowiche Creek, Wide Hollow Creek, and Moxee Drain. The TMDL evaluation will be used to develop a water cleanup plan that directs specific activities to reduce or remove pollutant sources. The project has five data and analysis objectives:

1. Identify FC bacteria loads by reach and from specific sources along Cowiche and Wide Hollow Creeks and Moxee Drain under various seasonal or hydrological conditions.

2. Determine the cumulative FC bacteria loads and calculate loading capacities along key points in Cowiche and Wide Hollow Creeks and Moxee Drain.

3. Estimate the FC count and load reductions necessary to meet the loading capacities.

4. Determine the percent E. coli and Klebsiella bacteria in some FC samples for better source identification and treatment.

5. Assign FC wasteload allocations to NPDES-permitted wastewater and stormwater sources, and estimate background and nonpoint FC load allocations.

Sampling Design

The project objectives will be met through characterizing annual and seasonal FC bacteria loads in Cowiche and Wide Hollow Creeks and Moxee Drain. At least one year of FC and flow data collection will be required to get basic FC concentration and loading data in various reaches of the three waterbodies.

The sampling design will use a fixed network of sites sampled once or twice monthly and a set of synoptic surveys conducted to characterize certain sources (Table 9). A special sample holding time study will be conducted first in December as described later in the Quality Control Procedures section. The fixed network will emphasize receiving water quality in the three streams and their major tributaries. The synoptic surveys will be used to characterize industrial and municipal stormwater sources, or to characterize irrigation returns during the irrigation season. Monitoring work will be more intensive in the months of April through October because historical data suggest this to be the critical period for elevated FC counts.

Fecal coliform bacteria samples will be collected at each site during both types of surveys. FC counts for each site will be compared to state criteria or permit limits. Instantaneous FC loads will be estimated at each site using the best available discharge data. FC correlations with chloride and TSS concentrations, turbidity data, and discharge volumes will be tested. If possible, seasonal and annual FC loads will be estimated from regression analyses of the results (Cohn et al., 1992; Christensen, Rasmussen, Jian, and Ziegler, 2001). Loads estimated at individual sites and within reaches will be compared to adjacent loads to characterize potential areas of excessive FC loading or areas of FC losses.

E. coli and percent KES (Klebsiella, Enerobacter, and Serratia) will be collected from selected sites. E. coli and percent KES will help to characterize wastes from various sources. For example, samples with a large number of E. coli would more likely come from an animal source than those with a high percentage of KES. A higher percentage KES would indicate bacteria from decaying vegetation. Future decisions about the types of Best Management Practice (BMPs) and specific source identification procedures could depend on this information.

Other samples will be taken to assist with source identification and general water quality characterization. Turbidity and total suspended solids (TSS) will be taken at a number of sites. Bacteria are often associated with sediment or particulate material. Strong correlations between these parameters would be helpful in making load estimates. Chloride samples can be used to identify areas with new water or waste inputs, or to trace waste sources downstream. Field measurements of temperature, conductivity, pH, and dissolved oxygen (DO) generally indicate water quality in terms of multiple beneficial uses.

Continuous streamflow data will be obtained from four stream gaging stations:

- Moxee Drain at Birchfield Road (USBR).
- Wide Hollow Creek upstream of Main Street (Ecology).
- Wide Hollow Creek upstream of Randall Park (Ecology).
- Cowiche Creek at Powerhouse Road (Ecology in a USBR gage house).

The sites on Wide Hollow Creek are being established by the Ecology’s Stream Hydrology Unit (SHU). The U.S. Bureau of Reclamation will supply data from their stream gage on Moxee Drain. The SHU is working with USBR to update the Cowiche Creek stream gage equipment. Instantaneous discharge measurements will be made at all other sites by direct means or by using a staff gage.

Daily rainfall data will be obtained from local sources. A meteorological station or several tipping-bucket rain gages will be installed to record rainfall intensity and duration for the storm event sampling, if the available Ecology equipment are reliable.

Table 9. Proposed Distribution of Fixed-Network and Synoptic Monitoring Surveys for the Yakima Tributaries Fecal Coliform TMDL Study for December 2004 to December 2005.

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fixed Network	1	1	1	1	2	2	2	2	2	2	2	2	2
Synoptic	0*	1	0	1	1	0	1	1	1	1	0	1	0

* Special sample holding time study.

The fixed-network, synoptic surveys, and the holding time study provide specific types of data needed to accomplish the objectives of the project. Station locations, sampling frequency, and secondary parameters will vary between the two types of surveys. The location and number of stations are subject to change depending on field conditions and analytical results.

Fixed-Network Monitoring

Data from the fixed-network will provide FC data sets to meet the following needs:

- Provide an estimate of the annual and seasonal geometric mean and 90th percentile statistics FC counts. The schedule should provide at least 22 samples per site to develop the annual statistics and 13 or 14 samples per site for the irrigation season.
- Provide reach-specific FC load and concentration comparisons to define areas of increased FC loading (e.g. from tile drains, malfunctioning on-site systems, and livestock) or FC decreases (e.g. settling with sediment, die-off, or diversion). With accurate discharge monitoring, FC loads diverted to irrigation or other uses can be separated from FC load losses from die-off or settling. Tributary and source loads also can be estimated.
- Help delineate any jurisdictional responsibilities for FC sources.
- Identify if certain land uses affect instream changes in FC loads.

The fixed-network sites will be sampled twice monthly in nine of the 13 months from December 2004 through December 2005. During four months (December – March), the fixed-network will be sampled once a month (Table 9). As presented earlier, the historical data suggest that the colder months are less critical for chronic FC problems in the study area. Schedules may change depending on flow conditions, site accessibility due to weather conditions, and staff availability.

Instantaneous measurements will include pH, DO, conductivity, discrete stream temperature, and discharge at each station. Samples for chloride and FC will be collected at each site. The sites at the mouth of each of the three creeks and a select set of other stations will be sampled for one or more of the following laboratory analyses: total suspended solids, turbidity, E coli, and percent KES.

The locations of the fixed-network water quality stations are listed in Table 10. Stations were selected to distinguish tributary from mainstem contributions and to distinguish among residential, agricultural, and recreational contributions within defined jurisdictions. Major tributaries and drains to each creek will be sampled as close to their confluence with the mainstem as possible. There are 29 tentative sites: 8 sites in the Moxee Drain Watershed, 11 in the Wide Hollow Creek Watershed, and 10 sites in the Cowiche Creek Watershed. Arrangements will be made to split effluent samples with the two WWTPs. Sites may be added or removed from the sampling plan depending upon access and new information provided during the QA Project Plan review.

Table 10. Sites Tentatively Selected in the Yakima Tributaries Study Area for the Fixed-Network.

Watershed or Sub-Watershed	Map ID	Road Crossing or Access	Site Purpose
Cowiche Creek	CW-0	Downstrm of US Route 12	Mouth of Cowiche Creek
Cowiche Creek	CW-1	Power House Road Bridge	Gage and below Canyon
Cowiche Creek	CW-1.5	Zimmerman Road Bridge	Ecology site 38G120
South Fork Cowiche Creek	CW-2	Pioneer Road	Confluence with North Fork
South Fork Cowiche Creek	CW-4	Cowiche Mill Road	Downstream of Wildlife area
North Fork Cowiche Creek	CW-3	Mahoney Road	Confluence with South Fork
North Fork Cowiche Creek	CW-5	Livengood Road Bridge	Downstream of WWTP
Cowiche Regional WWTP	CRW	Effluent channel to Creek	Final effluent + combined
North Fork Cowiche Creek	CW-6	Rozenkranz Road Bridge	Upstream of Tieton
North Fork Cowiche Creek	CW-7	French Road	Above Dam – background
Moxee Drain	M-1	Thorp Road	Mouth of Moxee Drain
Moxee Drain	M-3	Birchfield Road	303(d) reach & gage site
Moxee WWTP	MCW	Effluent channel	Final effluent at outfall
Tributary to Moxee Drain	M-7	Beaudry Road	WWTP and runoff channel
Hubbard Canal Return	M-5	Bell Road	Hubbard Canal?
Moxee Drain	M-8	Beauchene Road	Above join with other drains
Moxee Drain	M-9	Walters Road	Below Roza Canal
Moxee Drain	M-10	Prairie Dog Road Crossing	Start of Drain - background
Wide Hollow Creek	WH-1	Main Union Gap	Last free-flowing part of WH
East Spring Creek	WH-2	Spring Cr East	Tributary to WHC
Spring Creek	WH-3	E of Main	Tributary to WHC
Wide Hollow Creek	WH-4	16th Ave	Union Gap/Yakima boundary
Wide Hollow Creek	WH-6	40th Ave	Downstream of Randall Park
Shaw Creek	WH-7	E of 80th Ave	Tributary to WHC
Wide Hollow Creek	WH-8	80th Ave	Yakima City limits
Wide Hollow Creek	WH-12	Dazet Road	Confluence with Cottonwood
Cottonwood Creek	WH-13	Dazet Road	Mouth of Cottonwood
Cottonwood Creek	WH-14	Moore Road	Surface flow-background
Wide Hollow Creek	WH-16	Stone Road	Surface flow-background

Synoptic Monitoring

The purpose of synoptic monitoring is to better characterize potential sources of FC loading to the study area streams. The focus of the monitoring will be stormwater, snowmelt run-off, and irrigation returns during seasons when these sources are active. We will attempt to sample runoff during storm events in January, June, September, and November. Snowmelt will be monitored in March. Irrigation and drainage improvement district (DID) outfalls will be sampled in April, July, August, and early October.

The stormwater sampling sites will be distributed among several outfalls under NPDES industrial and Phase II permits in the Wide Hollow Creek Watershed. Stormwater NPDES permits are required to have corresponding Wasteload Allocations (WLAs) set in TMDL studies. Therefore, this study must determine WLAs for each permit holder, i.e., for each facility or Phase II permit jurisdiction. The resources for this TMDL project are not adequate to cover all of the permit holders in the study area. Wide Hollow Creek has the most complex combination of stormwater and industrial permits. In contrast to Cowiche and Moxee Watersheds, historical data from Wide Hollow Watershed also suggest that winter FC counts do not meet state criteria.

Stormwater outfalls from the following types of uses are targeted:

- runoff from areas dominated by each of the following land uses: range, agriculture, residential (suburban and urban), and industrial/commercial.
- runoff from an interstate highway, a state route, and several county arterials.
- industrial and fresh fruit packing plant permit holders.

Key receiving water sites at NPDES Phase II stormwater permit holder jurisdictional boundaries will be included.

Potential sites or types of sites for stormwater and snowmelt monitoring are listed in Table 11. The list will be finalized before the January storm event. The ability to quickly and safely access some sites and obtain a representative sample will be a challenge. Permission to sample runoff at some locations is still required. The list does not include all industrial and general permit holders along Wide Hollow Creek, especially the fresh fruit packing general permit holders. The WLAs for fresh fruit-packing facilities are not expected to be significant because they are not an obvious source of FC loads.

Table 11. Potential Sites to Monitor Stormwater Sources and Effects in the Wide Hollow Creek Watershed During Three Synoptic Surveys.

Site Name	Site ID	Location	General Type	Specific Purpose
WHC Road at 91st	WH	WHC Road	Road runoff	County road charact.
	WH		Storm runoff	Rural resident charact.
	WH		Storm runoff	Agriculture character
WHC at 80th Avenue	WH	80th Ave	Receiving water	Phase II jurisdiction
Clasen Fruit & Cold Storage	WH		Fruit Storage	General permit WLA
	WH		Storm runoff	Orchard charact.
Borton & Sons	WH		Fruit Storage	General permit WLA
	WH		Storm runoff	Residential runoff
Western Recreational Veh.	WH	34th Ave	Industrial outfall	Permit WLA
WHC at 16th Avenue	WH	16th Ave	Receiving water	Phase II jurisdiction
Del Monte Foods 125	WH		Industrial outfall	Permit WLA
Eakin Fruit	WH	Union Gap	Fruit Storage	General permit WLA
Downtown Union Gap	WH		Storm runoff	Urban/commercial
Business Hwy. 97	WH	Main Street	Road runoff	Phase II / State route
Interstate 82 Outfall	WH		Road runoff	Phase II / Interstate
WSDOT Maintenance	WH	E.Spring Cr.?	Maintenance	Phase II WSDOT
WHC below Hwy 82	WH	Near Mouth	Receiving water	Cumulative effect

The stormwater and snowmelt data collected from these outfalls will be applied to the other permits in the study area. WLAs for facilities not monitored will be determined on a proportional size of facility basis while accounting for variations in treatment systems. Phase II stormwater WLAs in Moxee Drain and Cowiche Creek will be estimated using a unit load model based on data collected from similar sites in Wide Hollow Creek Watershed.

Eastern Washington storms are usually Type II--with very little onset rainfall and a short duration single peak. The storms are also geographically sporadic. Catching an adequate number of FC grab samples during a runoff event will be difficult to accomplish from Olympia. Automatic sequential, or composite, samplers are not recommended for collecting FC samples because of cross-contamination issues in the intake lines. Therefore, we plan to form a local team of Central Regional Office, Yakima County, and other volunteers to respond quickly to a storm event until the EA Program personnel can arrive.

If storm run-off persists long enough, grab samples will be collected two or three times from each outfall or receiving water site. The snowmelt event in March may be the most productive in terms of multiple sample collection. Data from the storm events will be applied to a unit load model to estimate annual FC load from the facility or jurisdiction.

The historical data suggest that the critical season for elevated FC counts occurs from about April or May to October or November. This is generally the period when water is being managed for irrigation uses. The FC sources may not necessarily be from irrigation practices, but the additional water used for irrigation operations may allow transport of bacteria from other sources along canals and drains. Data collected by Kendra (1988), USGS (Morace and McKenzie, 2002) and Yakima County (2004) suggest that irrigation return outfalls and drains often have elevated FC counts. In the nearby Granger Drain Watershed, elevated FC counts were associated with irrigation runoff from manure spread on fields and animal access to return drains (Bohn, 2001). Their FC counts can be highly variable, but generally they are significant FC loading sources in the study area.

The synoptic surveys will focus on the FC inputs from irrigation returns and DID outfalls in April, July, August, and early October. Potential sites for outfall monitoring are listed in Table 12. Permission to access and sample these sites is still required. Key receiving water sites that bracket groups of returns are not included, and will be finalized in the final QA Project Plan. Data from these surveys will be compared to mass balance calculations based on the fixed network data. FC loading capacity during the critical season, and the required load reductions will be calculated.

Table 12. Potential Synoptic Survey Sites for Irrigation and Drainage Improvement District (DID) Source Effects on Wide Hollow, Cowiche, and Moxee Watershed Fecal Coliform Loads.

Site Name	Site ID	Location	Watershed
DID 38 Outfall Into WHC	WH	NW corner of bridge on 64th Ave.	Wide Hollow
DID 48 Outfall Into WHC	WH	NW corner of bridge on 64th Ave.	Wide Hollow
DID 48 outfall Into ditch	WH	SW of 48th Ave. & Nob Hill Blvd.	Wide Hollow
DID 40 outfall Into WHC	WH	SE corner of Logan & 38th Ave.	Wide Hollow
Congdon Canal?	WH	Below confluence of Cottonwood Cr.	Wide Hollow
DID 4 by Outfall Into WHC	WH	MH-3 in Gardner Nursery.	Wide Hollow
Shaw Creek	WH	80th & Wide Hollow Rd.	Wide Hollow
DID 24 Outfall L2 Into WHC	WH	MH16- N. of Pioneer,W. of Cornell.	Wide Hollow
DID 24 Outfall L1 Into WHC	WH	MH1-on 3rd Ave. N of Ahtanum Rd.	Wide Hollow
Tieton Canal	WH	Wide Hollow and 96th Ave.	Wide Hollow
Canal/Drain	WH	West Pine between 4th and 5th	Wide Hollow
Tieton Canal Spillway	C	End of canyon at RM 2.4	Cowiche
Side Branch Return	C	At Weikel Road above canyon	Cowiche
Loop Return Below Cowiche	C	Thompson Road	Cowiche
Irrigation Return Behind Dam	C	French Road	Cowiche
Drain?	M	Near Beane Road & Hwy 24	Moxee
Drain?	M	Along LaFramboise Road	Moxee
Moxee Canal	M	Beaudry Road	Moxee
Hubbard Canal	M	Bell Road	Moxee
Lateral Return to Moxee	M	Bell Road	Moxee
Lateral Return to Moxee	M	North of Thorp Road	Moxee

Field and Laboratory Analyses

Field sampling and measurement protocols will follow those listed in the Watershed Assessment Section (WAS) protocols manual (Ecology, 1993). Field measurements at all sampling stations will include conductivity, DO, pH, and temperature. All meters will be pre- and post-calibrated in accordance with the manufacturer's instructions. Pre-, mid-survey, and post-checks with pH and conductivity standards will evaluate field measurement precision and bias. A minimum of 10% of all DO measurements will be checked by a Winkler titration. Duplicate Winkler samples will be collected periodically to verify the precision of the Winkler measurements.

Grab samples will be collected using WAS protocols (Ecology, 1993). Duplicate FC, E. coli, and percent KES samples will be collected in the field in a side-by-side manner for 20% of the samples collected during an individual survey. Samples will be collected in the thalweg and just under the water's surface.

Turbidity, chloride, and TSS samples will have 10% duplication for each survey. The creek or drain channels at most sites in the study area are narrow (< 10 ft) and turbulent. A single sample will be taken in the center of flow in those areas. Where the channel is broad (> 10 ft), samples will be equal-width composite of two or more sub-samples.

Stream discharge information will be obtained at critical sampling locations to provide loading information. Continuous stream gaging stations will be installed at two locations on Wide

Hollow Creek. Discharge will be measured and the continuous loggers maintained by the Ecology SHU staff. The U.S. Bureau of Reclamation (USBR) data collected from Cowiche Creek at Powerhouse Road (Station CGWW) and Moxee Drain at Birchfield Road (Station BICW) will be obtained from the Yakima Project Office. Project staff and local cooperating agencies will provide additional flows at all other sites.

Estimation of discharge and instantaneous flow measurements will follow the SHU protocols manual (Ecology, 1999). Discharge volumes will be calculated from continuous stage height records and rating curves developed prior to, and during, the project. Stage height will be measured by pressure transducer and recorded by a data logger every 15 minutes. All data loggers will be downloaded monthly. Staff gages and/or capacitive probes will be installed at other selected sites. During the field surveys, discharge will be measured at selected stations and/or staff gage readings will be recorded. A flow rating curve will be developed for sites with a staff gage.

Daily rainfall data will be obtained from local sources. If equipment is fit for field use, a meteorological station may be installed to record rainfall intensity and duration for the storm event sampling. Tipping-bucket rain gages may be installed at two or three locations within the study area to monitor hourly rainfall.

Grab samples will be collected directly into pre-cleaned containers supplied by Manchester Environmental Laboratory (MEL) and described in the MEL User's Manual (2003). Sample containers, volumes, preservation requirements, and holding times are listed in Table 13. Samples for laboratory analysis will be stored on ice and delivered to MEL within 24 hours of collection. Microbiological and analytical methods, expected range of sample results, and method reporting limits are listed in Table 14. The expected range of sample results are based on historical data from the study area. The reporting limits of the methods listed in the table meet the expected range of results and the required level of sensitivity to meet project objectives.

Table 13. Containers, Preservation Requirements and Holding Times for Samples Collected During the Yakima Area Creeks Study. All Information in the Table is from the MEL User's Manual (MEL, 2003).

Parameter	Sample Matrix	Container	Preservative	Holding Time
Fecal Coliform	Surface water, WWTP effluent, & runoff	250 or 500 mL glass/poly autoclaved	Cool to 4ºC	24 hours
Escherichia coli	Surface water, WWTP effluent, & runoff	250 or 500 mL glass/poly autoclaved	Cool to 4ºC	24 hours
% KES	Surface water, WWTP effluent, & runoff	250 or 500 mL glass/poly autoclaved	Cool to 4ºC	24 hours
Total Suspended Solids	Surface water, WWTP effluent, & runoff	1000 mL poly	Cool to 4ºC	7 days
Turbidity	Surface water, WWTP effluent, & runoff	500 mL poly	Cool to 4ºC	48 hours
Chloride	Surface water, WWTP effluent, & runoff	500 mL poly	Cool to 4ºC	28 days

Table 14. Microbiological and Analytical Methods, Analytical Reporting Limits, and Expected Range of Results for Samples Collected During the Yakima Area Creeks TMDL Project.

Parameter	Expected Range	Reporting Limit	Analytical Method
Fecal Coliform	1 – 20,000 cfu/100 mL	1 cfu/100 mL	SM MF 9222D
Escherichia coli	1 – 20,000 cfu/100 mL	1 cfu/100 mL	EPA 1103.1 (mTEC2)
% KES	1 – 100 %	1%	Manchester SOP
Total Suspended Solids	1 – 1,000 mg/L	1 mg/L	SM 2540D
Turbidity	1 – 800 NTU	1 NTU	SM 2130
Chloride	0.1 – 300 mg/L	0.1 mg/L	SM 4110C

SM = Standard Methods for the Examination of Water and Wastewater, 20th Edition (APHA, AWWA and WEF, 1998) EPA = EPA Method Code.

Measurement Quality Objectives

The measurement quality objectives are presented in Table 15. The laboratory's measurement quality objectives and quality control procedures are documented in the MEL Lab Users Manual (MEL, 2003).

Table 15. Targets for Precision and Reporting Limits for the Measurement Systems.

Analysis	Duplicate Samples Relative Percent Difference (RPD)	Concentrations of Interest Concentration or Measurement Units
Field Measurements		
Velocity*	0.1 ft/s	0.05 – 5 feet/second
pH*	0.05 s.u.	1 – 14 s.u.
Water Temperature*	0.025° C	1° C to 40° C
Dissolved Oxygen	2.5% RPD	0.1 mg/L to 20 mg/L
Specific Conductivity	5% RPD	1 – 1000 umhos/cm
Laboratory Analyses		
Fecal Coliform (MF)	<25% RPD [2]	1 – 2 x 10^4 cfu/100 mL
Escherichia coli	<25% RPD [2]	1 – 2 x 10^4 cfu/100 mL
% KES	<25% RPD [2]	1% – 100%
Total Suspended Solids	<20% RPD	1 – 1 x 10^3 mg/L
Turbidity (Ratio Turbidimeter)	<20% RPD	1 – 1 x 10^3 NTU
Chloride	<5% RPD	0.1 – 1000 mg/L

* as units of measurement, not percentages.
[2] lognormal counts.

The targets for analytical precision in Table 15 are based on historical performance by the MEL for environmental samples taken in freshwaters around the state by the EA Program. Bias is also a component of data accuracy; however, bias from the true value is very difficult to determine for this set of parameters. Bias in field measurements will be minimized by calibration against standards and alternate methods of analysis, e.g. Winkler DO titrations. A formazin primary standard is used quarterly along with a daily gelex secondary standard to calibrate the turbidimeter at MEL. Calibration standards for microbiological analyses and TSS are not available. Bias in microbiological samples from holding time differences will be investigated by interlaboratory analyses. The details of this procedure are described in the next section, Quality Control Procedures.

Quality Control Procedures

Total variation for field sampling and analytical variation will be assessed by collecting duplicate samples. Bacteria samples tend to have a high percent Relative Percent Difference (RPD) between replicates compared to other water quality analyses. Bacteria samples will be assessed by collecting duplicates for approximately 20% of samples in each survey. Ten percent of the TSS, turbidity, and chloride samples will be duplicated. MEL routinely replicates sample analyses in the laboratory to determine the presence of bias in analytical methods. The difference between the field duplicates and the laboratory replicates is an estimate of the sample field variability.

If the QA/QC measurement requirements and objectives in Tables 14 and 15 can be met, all samples will be analyzed at MEL. The laboratory's measurement quality objectives and quality control procedures are documented in the MEL Lab Users Manual (MEL, 2003). MEL will follow standard quality control procedures (MEL, 2003). Field sampling and measurements will follow quality control protocols described in Ecology (1993). If any of these quality control procedures are not met, the associated results will be qualified and used with caution, or not used at all.

Standard Methods (APHA, AWWA and WEF, 1998) recommends a maximum holding time of eight hours for microbiological samples (six hours transit and two hours laboratory processing) for nonpotable water tested for compliance purposes. The MEL has a maximum holding time for microbiological samples of 24 hours (MEL, 2003) that is recommended by Standard Methods (APHA, AWWA, and WEF, 1998) for drinking water samples (<30 hours) and other types of water tested when compliance isn't an issue (<24 hours). Samples collected in the morning and sent to MEL from Yakima will not be processed within 6 hours, and those sampled before 10 AM may not be processed within 24 hours.

To identify any problem with holding times, a comparison study will be conducted at MEL. Ten FC samples will be collected in 500 mL bottles and each will be split into two 250 mL bottles. The samples will be driven to the MEL within 6 hours. One set of the split samples will be analyzed upon delivery. The other set will be stored overnight and analyzed the next day. Replicates will be compared to the Measurement Quality Objectives (MQOs) in Table 15.

If the samples do not meet the MQOs (i.e. the difference between the two sets is greater than what we expect from duplicate samples), we will contract with a local laboratory for the microbiological analyses. The Yakima-area laboratories listed in Table 16 are potential candidates for this QA analysis. Since there are many kinds of FC and E. coli methods, some research on method compatibility will be necessary before arrangements can be made.

Table 16. Yakima-Area Laboratories Accredited for Fecal Coliform Analysis Using the Membrane Filter Technique (Ecology, 2004a).

Laboratory	City	Address	Contact Phone
Cowiche Wastewater Treatment Plant Laboratory	Cowiche	1160 Livengood	(509) 678-5877
Moxee Wastewater Treatment Plant Laboratory	Moxee	PO Box 249	(509) 575-8851
Naches Wastewater Treatment Plant Laboratory	Naches	PO Box 95	(509) 653-2881
Roza-Sunnyside Board of Joint Control WQ Lab	Sunnyside	PO Box 239	(509) 837-6980
Valley Environmental Laboratory	Yakima	407 North First Street, Suite 3	(509) 575-3999
Yakima Regional Wastewater Plant Laboratory	Yakima	2220 East Viola St	(509) 575-6133

Data Verification and Validation

Laboratory-generated data reduction, review, and reporting will follow the procedures outlined in the MEL Users Manual (MEL, 2003). Lab results will be checked for missing and/or improbable data. Variability in lab duplicates will be quantified using the procedures outlined in the MEL Users Manual (MEL, 2003). If lab blanks show levels of analyte above reporting limits, the resulting data will be qualified and their use restricted as appropriate. A standard case narrative of laboratory QA/QC results will be sent to the project manager for each set of samples.

Field notebooks will be checked for missing or improbable measurements before leaving each site. Field-generated data will be entered into EXCEL® spreadsheets (Microsoft, 2001) as soon as practical after returning from the field. The EXCEL® Workbook file or will be labeled "DRAFT" until data verification and validity are completed. Data entry will be checked by the field assistant against the field notebook data for errors and omissions. Missing or unusual data will be brought to the attention of the project manager for consultation. Valid data will be moved to a separate file labeled "FINAL."

As soon as FC data are verified, the laboratory microbiologist will notify the project manager by electronic mail or by phone of FC results greater than 200 cfu/100 mL. The project manager will notify the CRO Client Staff Contact and Water Quality Section Manager by electronic mail of these elevated counts in accordance with EA Program Policy 1-03. The CRO Client Staff Contact will notify local authorities or permit managers as necessary.

Data received from MEL by LIMS will be checked for omissions against the "Request for Analysis" forms by the field lead. Data can be in EXCEL® spreadsheets (Microsoft, 2001) or download tables from Ecology's Environmental Information Management (EIM) system. These tables and spreadsheets will be located in a file labeled "DRAFT" until data validity is completed. Field duplicate sample results will be compared to quality objectives in Table 15. Data requiring additional qualifiers will be reviewed by the project manager. After data validity and data entry tasks are completed, all field, laboratory, and flow data will be entered into a file labeled "FINAL," and then into the EIM system. EIM data will be independently reviewed by another EA Program field assistant for errors at an initial 10% frequency. If significant entry errors are discovered, a more intensive review will be undertaken. At the end of the field collection phase of the study, the data will be published in a data summary.

Data Analysis and Use

Data analysis will include evaluation of data distribution characteristics and, if necessary, appropriate distribution of transformed data. Tests for correlations between FC, TSS, and turbidity will begin as soon as groups of data are validated. Discharge data, chloride results, and conductivity measurements will be frequently reviewed during the field data survey season to check longitudinal water balances. Estimation of univariate statistical parameters and graphical presentation of the data (box plots, time series, regressions) will be made using WQHYDRO (Aroner, 2003) and EXCEL® (Microsoft, 2001) software.

Data will be applied to several TMDL methods of evaluation. The statistical rollback method (Ott, 1995) will be applied to FC data distributions to determine target count reductions along key reaches of each waterbody during critical conditions. Ideally, at least 20 data are needed from a broad range of hydrologic conditions to determine an annual FC distribution. If sources of FC vary by season and create distinct critical conditions, seasonal targets may be required. Fewer data will provide less confidence in FC reduction targets, but the rollback method is robust enough to provide general targets for planning implementation measures.

Fecal coliform mass balance calculations by reach will be performed on a reach basis using sample counts with field discharge and continuous discharge measurements. Application of FC loads to NPDES permits will follow permit language concerning duration and critical conditions.

Project Organization

The roles and responsibilities of Ecology staff are as follows:

- **Joe Joy** Project Manager, Environmental Assessment Program, Water Quality Studies Unit: Responsible for overall project management. Defines project objectives, scope, and study design. Author of the project QA Project Plan. Manages data collection program. Writes TMDL technical study report.

- **Nuri Mathieu,** Field Lead, Environmental Assessment Program, Water Quality Studies Unit: Assists in defining project objectives, scope, and study design. Coordinates field surveys with CRO and local staff members. Responsible for data collection, entering project data into the EIM system, and data quality review.

- **Ryan Anderson**, Overall TMDL Project Lead, Water Quality Program, Central Regional Office: Acts as point of contact between Ecology technical study staff and interested parties. Coordinates information exchange, technical advisory group formation, and organizes meetings. Acts as local field crew leader for storm surveys. Supports, reviews, and comments on QA Project Plan, and technical report. Is responsible for implementation, planning, and preparation of TMDL document for submittal to EPA.

- **TBD**, Unit Supervisor, Water Quality Program, Central Regional Office: Responsible for approval of TMDL submittal to EPA.

- **Will Kendra,** Section Manager, Environmental Assessment Program, Watershed Ecology Section: Responsible for approval of project QA Project Plan and final TMDL report.

- **Karol Erickson,** Unit Supervisor, Environmental Assessment Program, Water Quality Studies Unit: Reviews and approves project QA Project Plan, the staffing plan, final TMDL report, and technical study budget.

- **Stuart Magoon, Will White, and Pam Covey,** Ecology Manchester Laboratory, Environmental Assessment Program: Provides laboratory staff and resources, sample processing, analytical results, laboratory contract services, and QA/QC data. Review sections of the QA Project Plan relating to laboratory analysis.

- **Chuck Springer,** Environmental Assessment Program, Stream Hydrology Unit: Responsible for the deployment and maintenance of continuous flow loggers and staff gauges. Responsible for producing records of hourly flow data at select sites for the study period.

- **Brenda Nipp**, Field Assistant, Environmental Assessment Program, Watershed Ecology Section: Conducts monitoring program under the supervision of Nuri Mathieu.

- **Cliff Kirchmer,** Quality Assurance Officer, Environmental Assessment Program: Reviews QA Project Plan and all Ecology quality assurance programs. Provides technical assistance on QA/QC issues during the implementation and assessment of project.

Project Schedule

The proposed schedule for the Yakima area tributaries FC TMDL project is as follows:

Table 17. Proposed Schedule for the TMDL Project.

Event	Date
Submit Draft QA Project Plan for Review	October 2004
Finalize QA Project Plan	December 2004
Sampling Surveys Begin	December 2004
Sampling Surveys End	December 2005
EIM Data Completion	March 2006
Draft Report to Supervisor	September 2006
Draft Report to Client and Peer Review	October 2006
Draft Report to External Stakeholders	November 2006
Final Report	February 2007

Laboratory Budget

The estimate for the laboratory budget and lab sample load in Table 17 is based upon the proposed schedule in Table 9. Microbiological analysis account for most of the costs, as would be expected. Since most months have more than one survey that occur on different weeks, monthly and weekly laboratory sample loads should not overload the microbiological or general chemistry units at the MEL. The greatest uncertainty in the laboratory load and cost estimate is with the synoptic survey work. A conscious effort will be made to keep the submitted number of samples within the estimate by sub-sampling stormwater from permitted facilities, DID outfalls, and irrigation returns.

Table 18. Yakima Area Creeks Fecal Coliform TMDL - The Number of Monthly Sample Submittals for Each Analysis, an Estimate of the Monthly Analytical Costs, and the Total Analytical Cost Estimate[2] for the Project.

	F. Coli	E. coli	% KES	TSS	Turbidity	Chloride	Cost
December	70	20	10	18	18	70	$3,520
January	75	30	15	24	24	75	$4,098
February	35	10	5	9	9	35	$1,760
March	75	30	15	24	24	75	$4,098
April	85	30	15	25	25	85	$4,689
May	70	20	10	18	18	70	$3,520
June	106	40	20	33	33	106	$5,858
July	85	30	15	25	25	85	$4,689
August	85	30	15	25	25	85	$4,689
September	106	40	20	33	33	106	$5,858
October	85	30	15	25	25	85	$4,689
November	106	40	20	33	33	106	$5,858
December	70	20	10	18	18	70	$3,520
Totals	1053	370	185	310	310	1053	**$56,846**

F.Coli = fecal coliform; E. coli = Escherichia coli; % KES = % Klebsiella, Enerobacter, and Serratia; TSS = total suspended solids.

Funds will be required to conduct the sample splits with a local laboratory (likely less than $700). This initially would involve ten samples. If a local laboratory is necessary to meet the QA/QC requirements for the microbiological analyses, then the cost of the project could go up.

[2] Costs include 50% discount for Manchester Laboratory

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