CHAPTER 5: PROBLEM IDENTIFICATION AND ANALYSIS

The hydrologic analysis and water quality study summarized in chapter 4 forms the basis for the identification and analysis of specific flooding, habitat, and water quality problems. Field work by staff and reports and complaints from citizens identified additional problem sites. This chapter presents an overview of each problem category, describes the specific problems in the basin, and analyzes alternative solutions. Preceding chapters described the existing characteristics of the basin; subsequent chapters recommend problem solutions.

5.1 FLOODING

Defining "problem flooding" proved to be a contentious issue for the Chambers Basin Citizen Advisory Task Force. The extent and impact of flooding varies widely around the basin, the county and the state. The flooding analysis did not determine if runoff from developed areas has increased wetlands, which was a concern of some task force members. Historic maps and surveys and reports from long-time residents indicate that the basin's wetlands have probably fluctuated up and down in size over the years in response to several factors, including drought and rain cycles, water table changes, construction and abandonment of drainage ditches, beaver activity, and filling, clearing and building for various land uses. The influence of past development practices on wetlands is impossible to separate from all the other factors. The analysis presented here depicts the current and future flooding areas, and limits "problem" descriptions to sites where flooding threatens homes, roads, or public health and safety. The term "problem flooding" refers only to those sites, in the problem descriptions below.

Flooding occurs naturally when storms cause rivers and streams to overflow their banks. Forests and natural vegetation intercept and absorb rainfall, preventing the rain from running off rapidly and flooding streams and property. Repeated flooding creates floodplain areas around streams, which absorb overflow waters and slow down the flows. Floodplain areas have developed unique ecosystems adapted to these conditions. Several of the floodplains in the Chambers basin contain wetlands with plants adapted to periodic inundation.

Flooding in developed areas results from several factors, including:

Increased Impervious Area. Development reduces the landscape's natural ability to moderate flooding because buildings and pavement cover the soil with surfaces impervious to water. Flooding problems are consequently likely to increase with development.

Several studies have found that when impervious coverage within a basin exceeds 10% to 15%, stream hydrology, water quality and habitat quality decline (Klein 1979; Schueler 1994). Impervious surfaces currently cover about 10% of the Chambers Basin. Approximately 28% of the developed area in the basin provides no stormwater management, and many of the remaining developments provide inadequate stormwater management.

Pothole Area Soils. Complex soil and drainage patterns in the pothole areas create the potential for localized flooding problems associated with development. Rainfall in these closed basins drains into potholes and eventually evaporates or infiltrates to ground water. The water level in potholes following storms depends on the rate and quantity of runoff entering the potholes, and the rate at which the water leaves the potholes through infiltration and evaporation.

Pothole bottoms sometimes contain muck soils and collected sediments that drain extremely slowly. In contrast, the surrounding sand-and-gravel soils rapidly infiltrate rainfall and reduce runoff into the potholes. As development reduces infiltration and increases runoff into potholes, higher water levels can flood adjacent homes.

Clogged Stormwater Facilities. In the Chambers basin, much of the stormwater runoff collected by antiquated stormwater systems drains into the ground through infiltration facilities such as dry wells and retention ponds. Facilities designed to infiltrate stormwater directly into the ground fail occasionally, usually because fine sediments contained in runoff clog them. Fine sediments come from road and construction site runoff.

Clogged stormwater facilities cause local flooding, often in residential neighborhoods, when the runoff backs up and spills out into streets and parking lots. Many infiltration facilities have never been cleaned of sediments or maintained, so they no longer function properly.

Inadequate Stormwater Facility Design. Many older system designs relied on less sophisticated methods to determine volumes of runoff than the methods available now. Frequently, those older systems were designed with inadequate capacity, causing stormwater runoff to back up and overflow onto roads and property.

Perched Water Tables. Layers of impermeable, clay-cemented till near the soil surface prevent water from infiltrating in some locations around the basin. These deposits create "perched" high water tables when the soil becomes saturated during the rainy season, which can flood stormwater facilities and lowlands. Map 7 indicates areas where till forms the surface soil, but hidden deposits of till may also occur anywhere throughout the outwash soils.

5.1.1 Hydrologic Modeling Assumptions

Future flooding potential was predicted by changing the hydrologic model to simulate the future when all available land has been fully developed. The hydrologic model assumed that development would proceed according to the future land uses proposed in the Thurston County Comprehensive Plan, May 1993 draft. The future conditions model also assumed:

1) 20% of all currently undeveloped land outside the Urban Growth Management Area (UGMA) will remain undisturbed.

2) All of the currently undeveloped land within the UGMA will be developed.
3) All the land in the "mostly undeveloped" sub-basins will be developed to the densities specified in the draft Comprehensive Plan.
4) Only the undeveloped land in the "mostly developed" sub-basins will be developed to the densities specified in the draft Comprehensive Plan.
5) Drainage routing will not change.
6) All the stormwater runoff from new development on outwash soils will be infiltrated, as required by the Thurston County Drainage Manual.
7) Lake and wetland area will not change.
8) Stormwater runoff from development on till soils will be required to meet the maximum standards for soils with no infiltration capacity.

5.1.2 Flooding Problems on Chambers Ditch

Currently, Chambers Ditch floods regularly in a few locations and does not threaten any homes, but development in the future could cause slightly more runoff to drain to the ditch. This section considers both existing and future problems.

Historical records indicate that the area around Chambers Ditch has flooded occasionally since near the beginning of this century. The Chambers Drainage District was originally created at the request of ditch-side landowners to fund ditch improvements that would reduce flooding and drain additional land for agriculture. Much of the basin has been developed since the drainage district was formed, and now runoff has increased and most of the land that drains to the ditch lies outside the drainage district.

The drainage ditch traverses flat land through most of its length. The vertical drop in the first mile below the outlet at Little Chambers Lake is only about 2′, and the drop from there to Yelm Highway, approximately 1 mile, is about 5′. The low gradient causes water to flow slowly through most sections of the ditch, even during periods of high runoff, which makes the area surrounding the ditch vulnerable to flooding.

Reported flooding on the ditch varies widely between landowners. Some report repeated flooding of their property while landowners at other locations along the ditch report little or no flooding. Reported flooding sites along the ditch include areas near Fuller Lane, Yelm Highway, 59th Court SE, 60th Loop SE, 62nd Avenue SE, Herman Road, Ferndale Court, and Donnelly Drive (see map 12). Most reported flooding was caused by clogged culverts.

Chambers Ditch Flooding Analysis

County staff analyzed the ditch hydrology in order to analyze the extent of flooding problems along the ditch. Staff surveyed the ditch, measuring elevations and cross-sections in several locations from Little Chambers Lake to 2365′ south of Yelm Highway and for about 1000′

east of Rich Road. Elevations from a previous survey were used for the wetland area at the lower end of the ditch, between Yelm Highway and Rich Road, and no cross sections were measured in that area.

The existing and future flows from the hydrologic analysis described in chapter 4 were routed down the ditch using a hydraulic modeling program, HEC-2, in order to determine the elevations of flood waters and locate specific problem sites. The HEC-2 analysis simulated flows with the ditch in both a maintained and an unmaintained condition, because inadequate maintenance can cause vegetation and debris in the ditch to reduce the velocity and increase the elevation of flows. The flood elevations were plotted onto topographic maps to determine the extent of flooding. Currently, the drainage district maintains the ditch only to just south of Yelm Highway; below there, a few landowners occasionally perform some maintenance.

Flooding Analysis Results

Figure 5-1 shows the projected future increase in Chambers Ditch flows at buildout, and figures 5-2A through 5-2D show the flooding that would result from the 100-year storm if the ditch was not maintained. The wetland boundaries mapped by Thurston Regional Planning Council were used to show the limits of flooding in the unsurveyed wetland area south of Yelm Highway. These limits may overstate the extent of actual flooding because they do not reflect small elevational differences within the flooded area. Additional surveying and analysis would give a better indication of flooding in that area.

The analysis found that, if the ditch **is** maintained, no problem flooding that threatens homes or roads will result. However, the water will overtop the banks on some undeveloped sites:

- the **existing 10-year** flows will flood one undeveloped parcel north of Yelm Highway and one undeveloped parcel east of 60th Loop; both are wetlands currently used for agriculture.
- the **existing 100-year** flows will cause flooding at the locations described above.
- the **future 100-year** flows will not cause flooding at any additional sites.

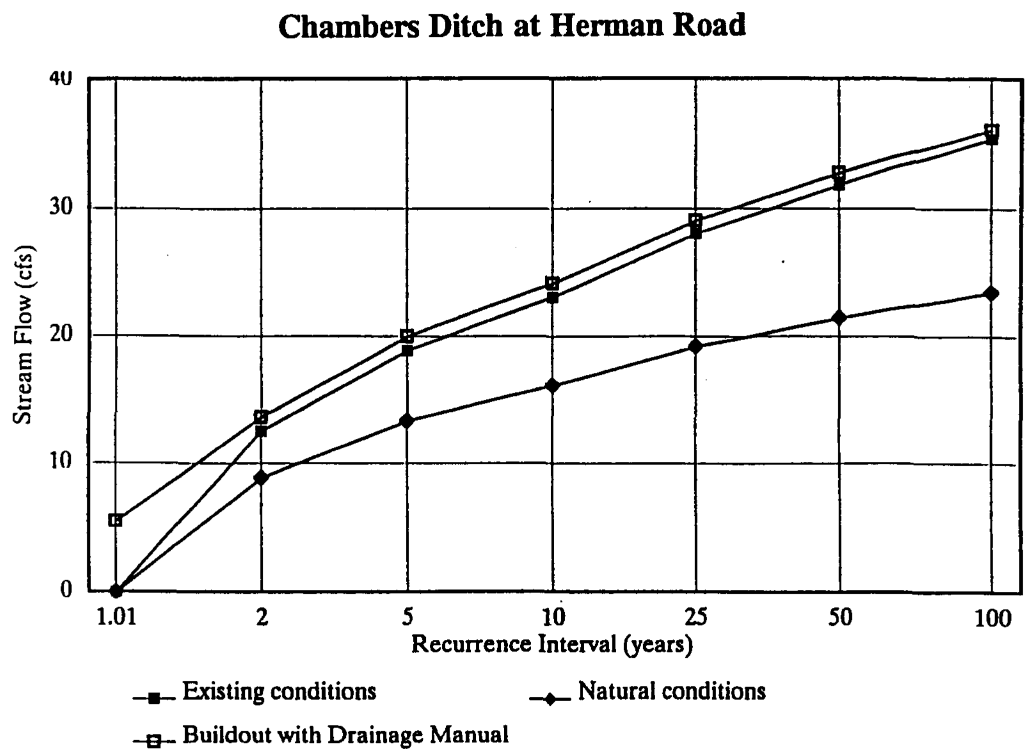
If the ditch **is not** maintained, problem flooding could threaten roads, homes or public health and safety at several locations:

- the **existing and future 10-year** flows will not cause flooding at any additional sites.
- the **existing 100-year** flows will cause flooding at three additional locations, and the ditch will approach capacity at several other locations.
- the **future 100-year** flow will cause flooding at six additional locations.
- the **existing and future 100-year** flows will fill the ditch to near maximum capacity at a few other locations.

Both properties which flood under all of the modeled **existing** conditions are currently used for agriculture. The Yelm Highway site contains a small riparian wetland. The site near 60th Loop contains a large wetland fed by groundwater and surface water that encompasses the junction of Chambers Ditch and the South Tributary. Both sites have homes and/or farm buildings which are not threatened by flooding.

The additional sites flooded by the **existing** 100-year flows are all flat, open, undeveloped land in agricultural areas. None of these sites contain structures which would be threatened by flooding.

The **future** 100-year flows will cause flooding of Herman Road and several properties between the lake and Yelm Highway. The flooding would not threaten any buildings, but would affect some driveways and several lawns and pastures. The 100-year flows would fill the ditch to near capacity just south of Yelm Highway, where overtopping could threaten an adjacent apartment complex.



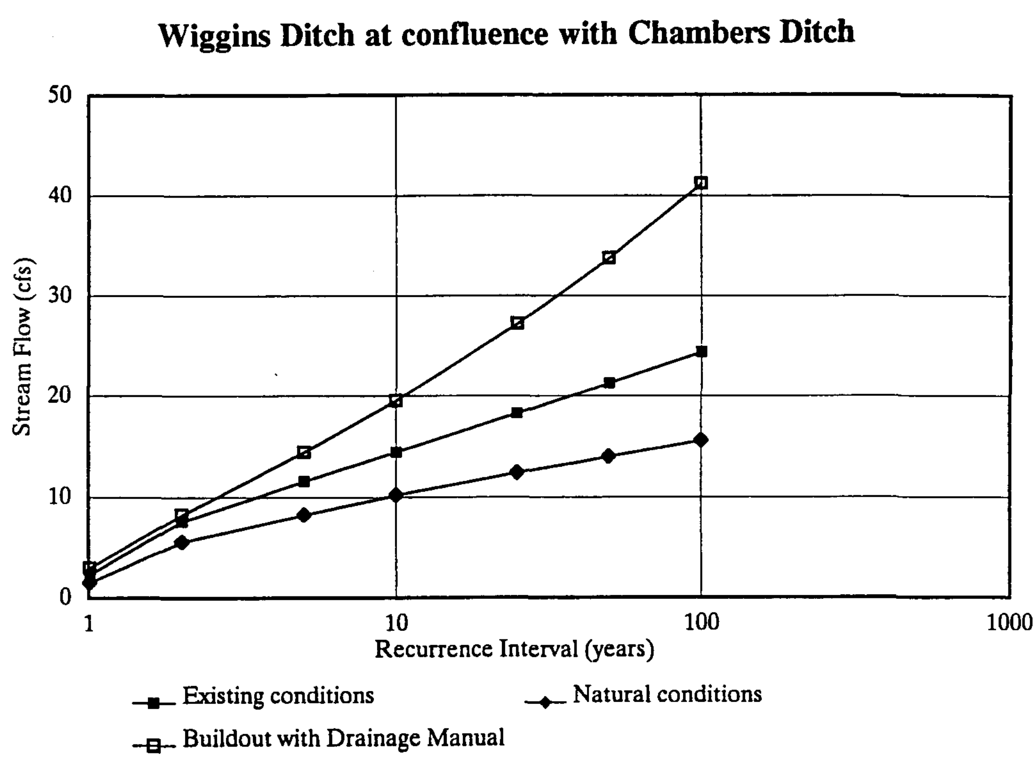
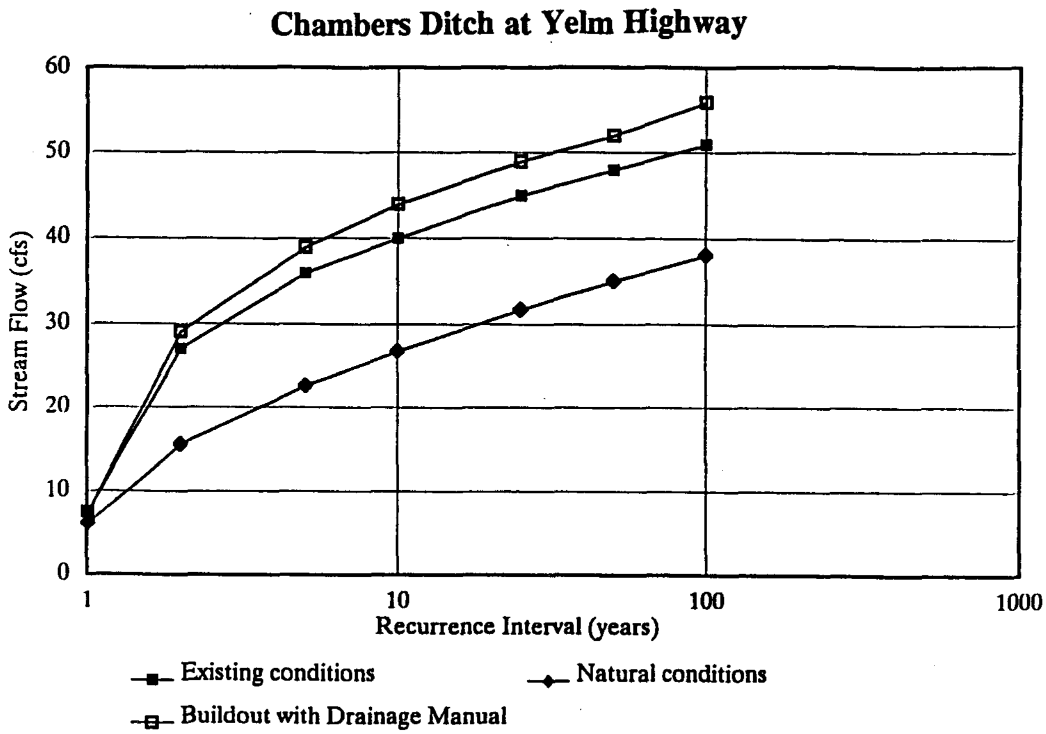


Figure 5-1A Flow vs. Recurrence - Chambers Basin



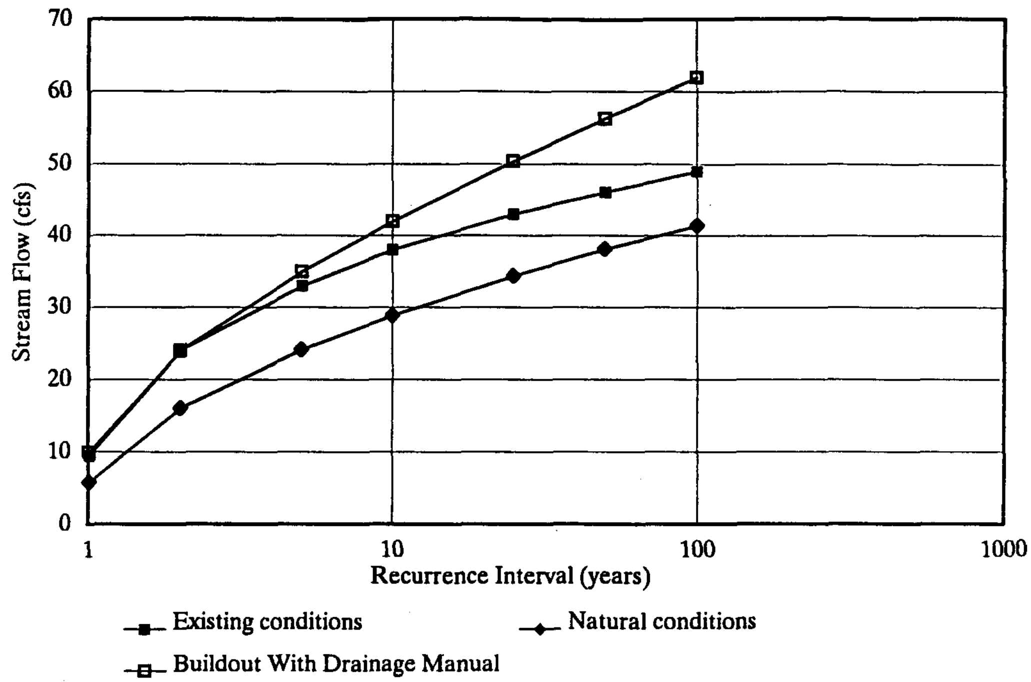
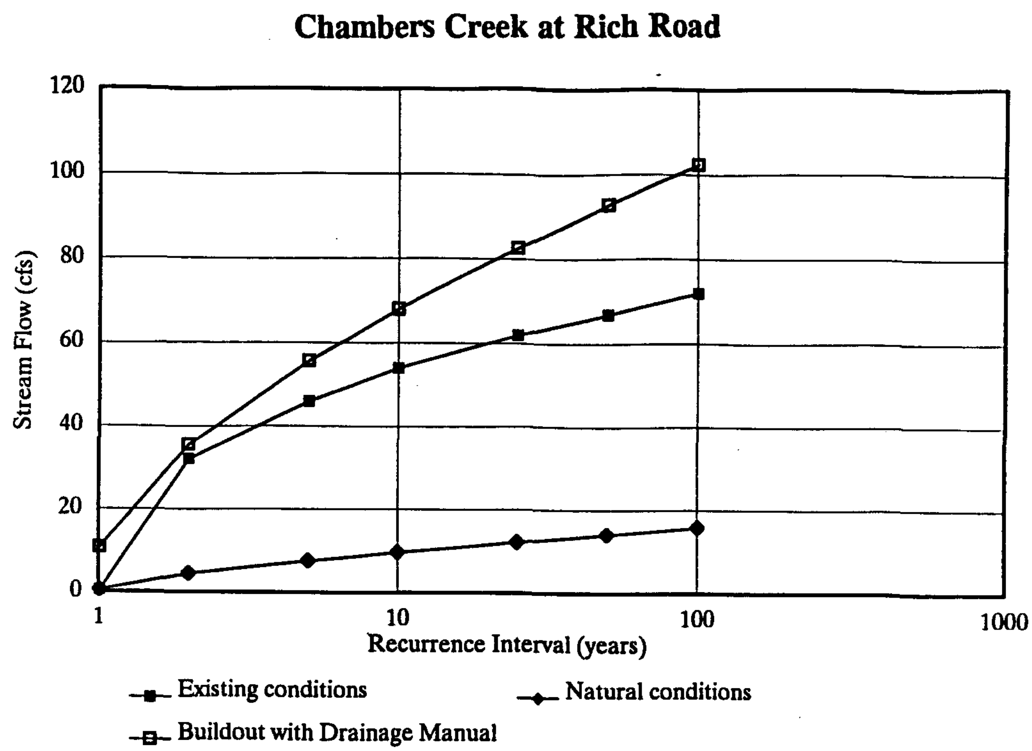


Figure 5-1B Flow vs. Recurrence - Chambers Basin



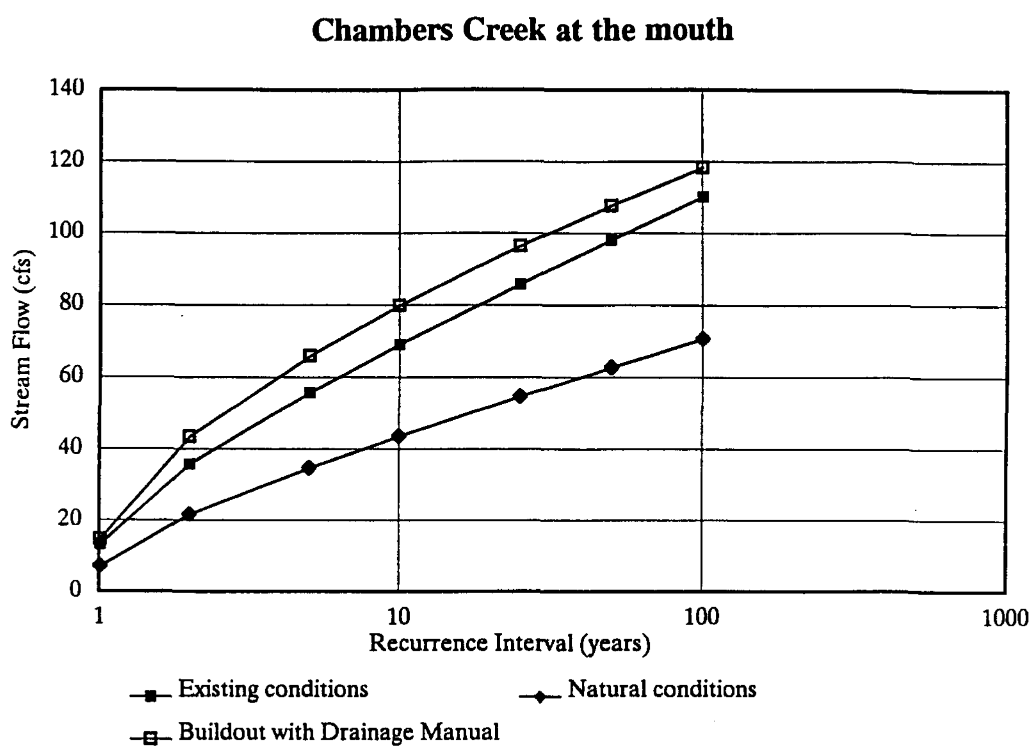


Figure 5-1C Flow vs. Recurrence - Chambers Basin

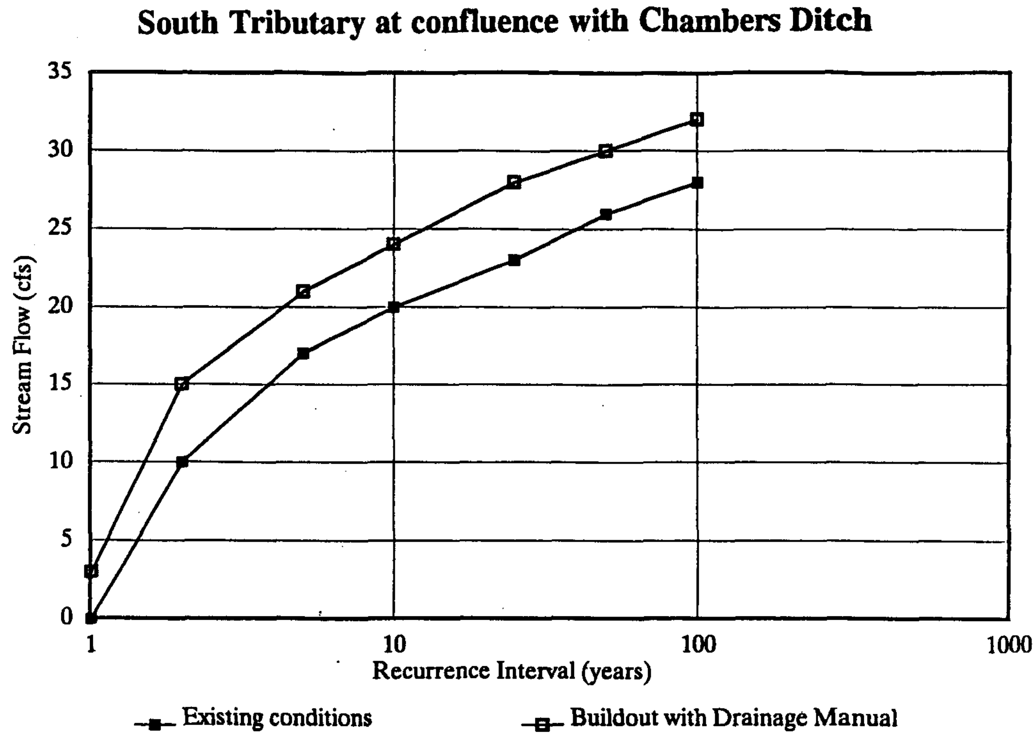


Figure 5-1D Flow vs. Recurrence - Chambers Basin

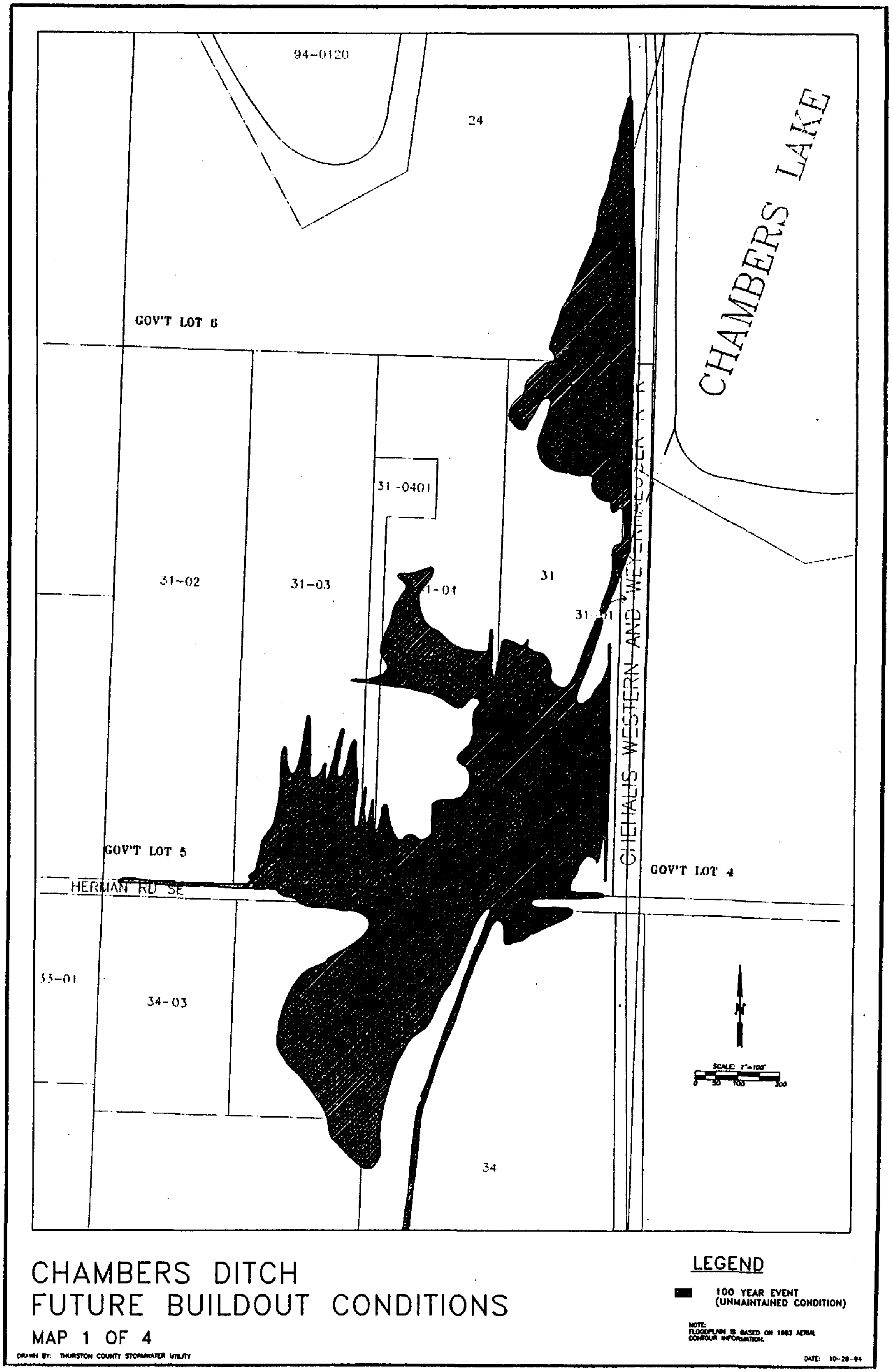


Figure 5-2A Chambers Ditch future flooding from the 100-year storm

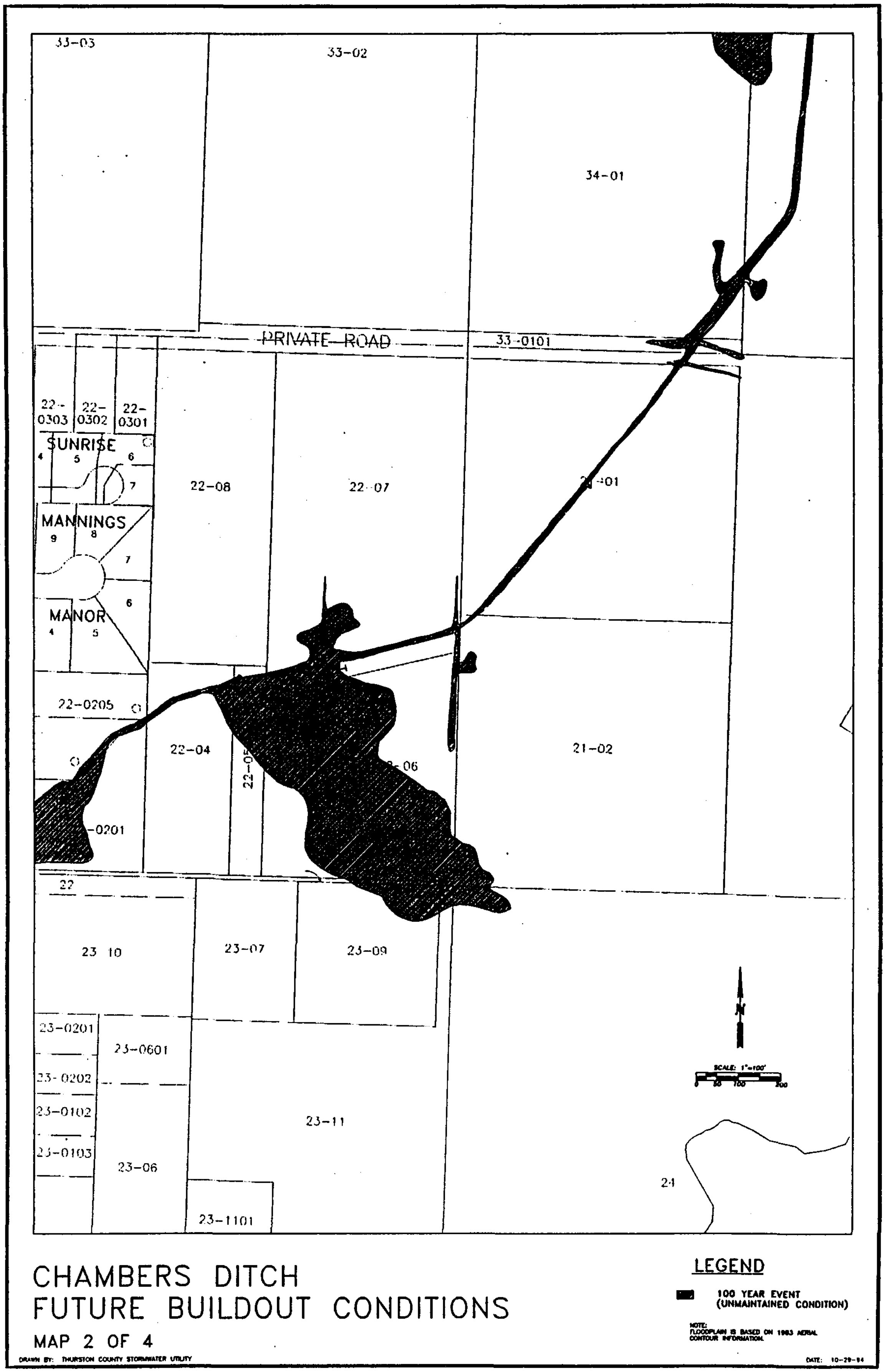


Figure 5-2B Chambers Ditch future flooding from the 100-year storm

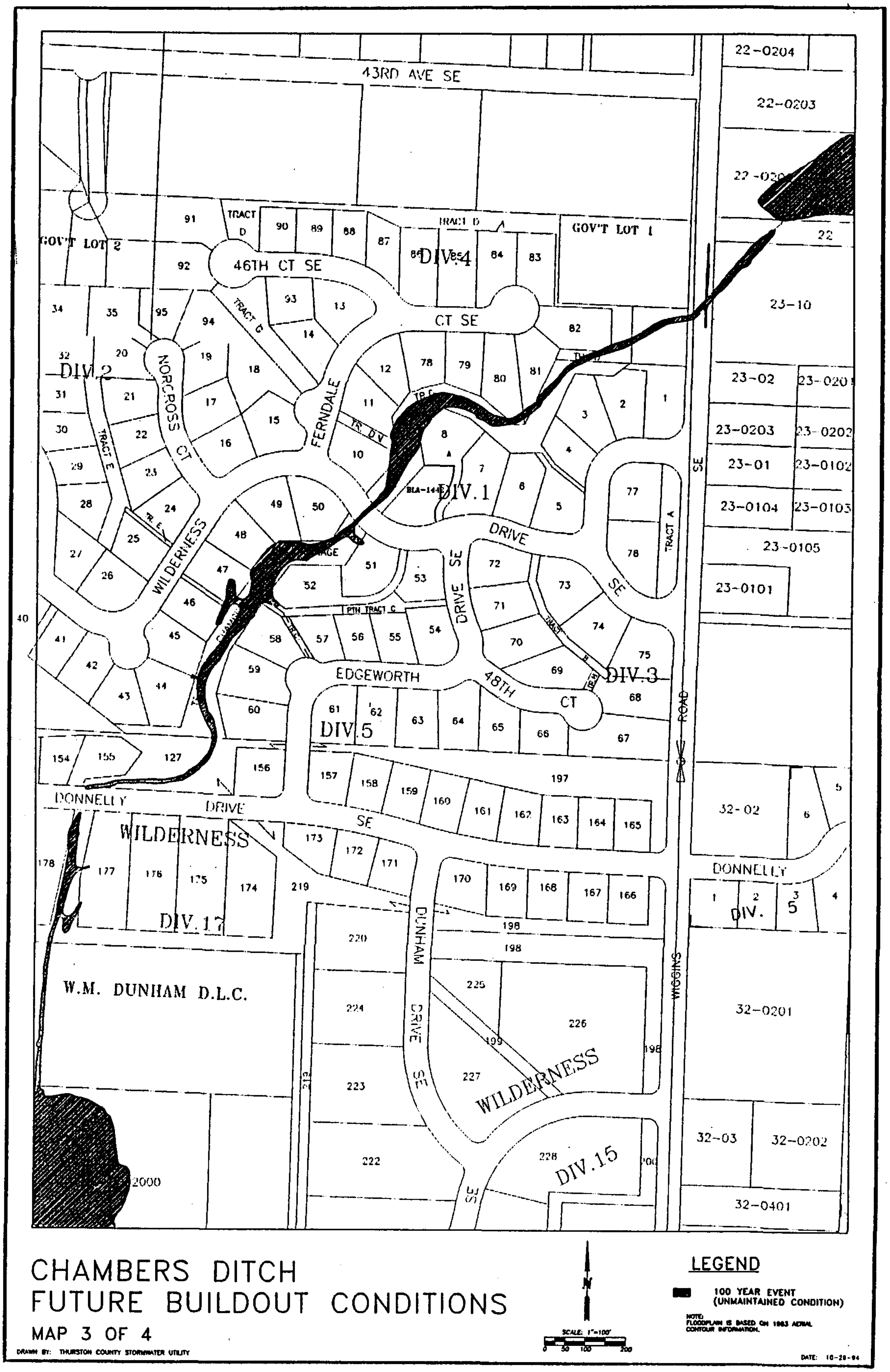


Figure 5-2C Chambers Ditch future flooding from the 100-year storm

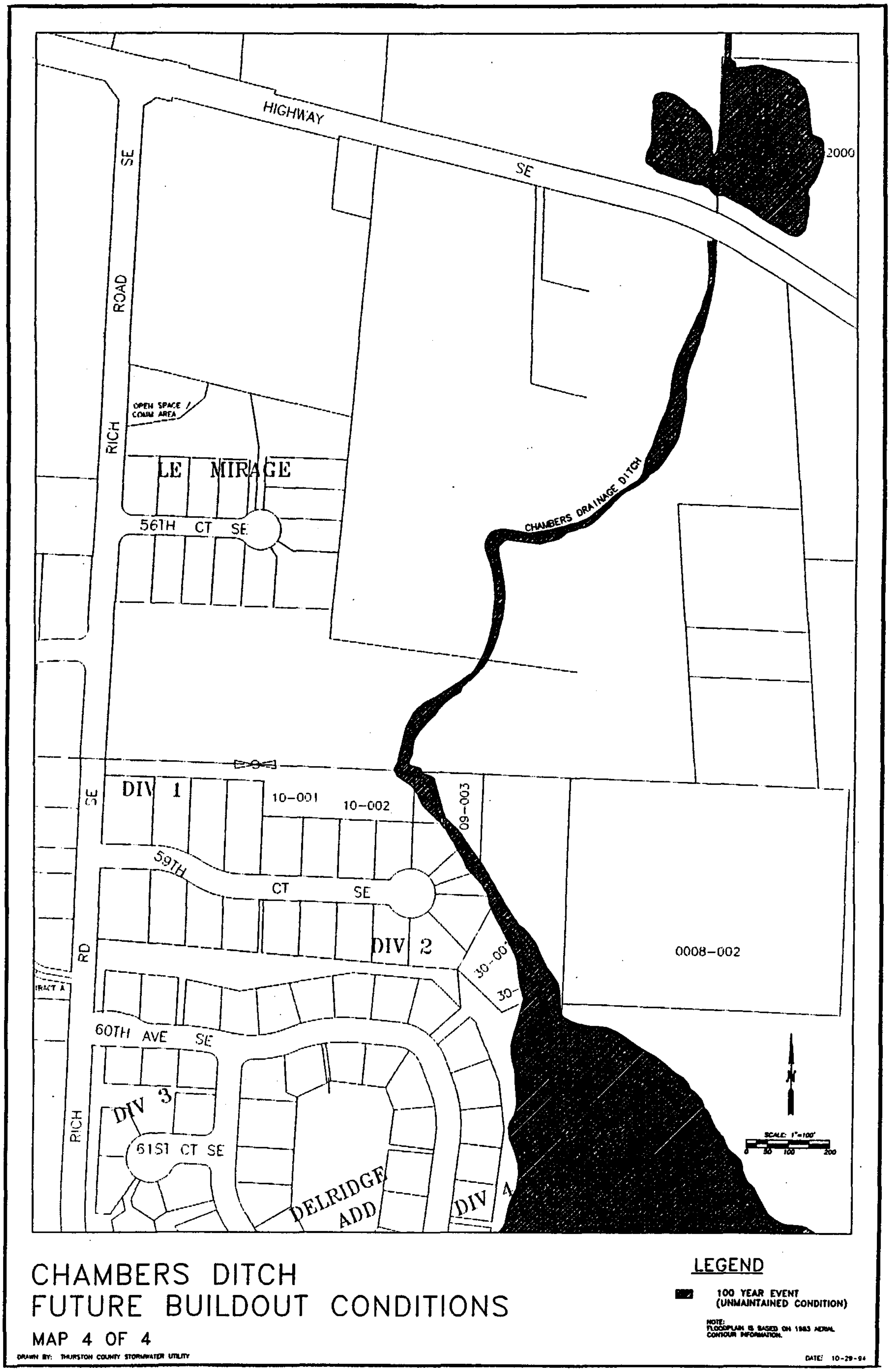


Figure 5-2D Chambers Ditch future flooding from the 100-year storm

Discussion and Analysis of Alternatives

Alternatives for reducing flooding along the ditch include:
1) Install trash racks on culverts
2) Increase the level of ditch maintenance
3) Expand the ditch capacity
4) Detain stormwater runoff in Little Chambers Lake
5) Detain stormwater runoff at other upstream locations
6) Educate homeowners on proper disposal of yard waste

Each of these measures could be implemented separately or in combination with others. Other alternatives, such as rerouting Chambers Lake to drain north to Woodland or Woodard Creeks, were dismissed due to cost, engineering and environmental obstacles.

1) Install trash racks on culverts. Trash racks could be installed on the mouths of the culverts under road crossings, to prevent large debris from clogging the culverts and causing roads and driveways to flood. However, they would not prevent accumulation of smaller debris such as lawn clippings, and they could increase clogging if they are not cleaned regularly, which would require increased maintenance frequency. Trash racks could be augmented with a neighborhood education effort about the importance of keeping the ditch clear, which could reduce the amount of waste placed in the ditch and help prevent debris from accumulating. When residents report flooded roads due to clogged culverts, county crews must remove debris from the culverts. Regularly maintained trash racks might reduce the frequency of these emergency call-outs, but they could also interfere with the crews' ability to use maintenance equipment in the culverts.

Installing and maintaining trash racks might reduce or eliminate problem flooding at four or more road crossings. Trash racks would not reduce flooding caused by high flows. The trash racks could improve fish passage in winter by eliminating blockages. They would not affect fish passage in summer because the ditch dries up.

2) Increase the level of ditch maintenance. The ditch could be brushed and mowed annually, and re-graded occasionally to maintain the configuration necessary to prevent problem flooding. The debris would be removed and disposed at the county composting facility or landfill.

Maintenance guidelines would be developed by the drainage district and the county in consultation with the appropriate state agencies, as required by the Thurston County Critical Areas Ordinance (TCC 17.15.930D), in order to have the least impact on downstream habitat. Maintenance activities would utilize Integrated Vegetation Management techniques that emphasize least-toxic, environmentally sensitive pest and weed control.

Maintenance of the ditch from the lake to Yelm Highway would significantly reduce problem flooding from the 10-year flows. The only flooding expected from the 10-year, maintained ditch flows is flooding of a few acres of undeveloped agricultural land near Yelm Highway (for which a development has been proposed), and the wetland above Rich Road.

Maintenance of Chambers Ditch from the lake to Yelm Highway would significantly reduce problem flooding from the 100-year flows. The only flooding predicted from the 100-year, maintained ditch flows would be at the sites near Yelm Highway and the wetland above Rich Road, which also flood from the 10-year, maintained ditch flows.

Modeling indicated that maintenance of the ditch below Yelm Highway would not prevent problem flooding at any additional sites from the 10-year or 100-year storm events. Digging out the ditch through the wetland above Rich Road would probably reduce flooding in the wetland from smaller, more frequent storms, but additional modeling would be required to confirm this. The wetland owner claimed that maintaining the ditch through the wetland would prevent flooding from the 10-year event.

The impact on fish and wildlife habitat of maintaining the ditch could be minimized by removing vegetation and accumulated sediment only from within the channel, and scheduling it during dry summer months. Sediment removal would probably be required infrequently, perhaps once every 10 years, and the channel would be revegetated. Mowing would have little impact to fish habitat because the ditch is mainly vegetated with grass, which has very low value as habitat. Modeling indicates that increased maintenance would not significantly increase downstream peak flows.

Increasing maintenance of Chambers Ditch would pose several challenges, such as establishing appropriate roles and responsibilities for the drainage district and the county, determining the appropriate level of flood protection, funding the program, assuring access, and addressing wetland regulations.

Roles and Responsibility. Reliable, ongoing ditch maintenance will require an organized group such as the drainage district, the county, or a homeowner association to be responsible for maintenance. Currently, the Chambers Drainage District maintains the ditch from Little Chambers Lake to 800′ below Yelm Highway. The Wilderness Homeowner Association has an agreement that the drainage district will maintain the ditch through Wilderness, and the homeowner association is not likely to want to take over that responsibility. Historically, the county never had the responsibility to maintain the ditch.

The Chambers Drainage District was approved by the county in 1919 at the request of local landowners in order to expand the ditch (see *History of Chambers Ditch* in chapter 3). Since then, the ditch sub-basin has developed and drainage to the ditch has increased significantly.

Most of the area draining to the ditch now lies outside the district's boundaries. The district also maintains a downstream segment of the ditch that lies beyond its boundaries. The district could continue with responsibility to maintain the ditch and expand its program to include the activities described above.

The county could maintain the ditch beyond the drainage district's boundaries, and it could assume the drainage district's responsibilities if the district dissolved. Currently, the county program only includes maintaining drainages within the public right-of-way to prevent road flooding. The county does not maintain ditches on private property or attempt to prevent flooding of private property; however, local fire departments will pump out flooded basements at the request of a homeowner. If the county assumed maintenance responsibility for the ditch, it would represent a fundamental change in the county's flood protection goals.

Levels of Flood Protection. The county and the drainage district may provide different levels of flood protection, due to different goals. The existing county drainage maintenance program is intended to protect public health and safety, and protect public resources such as water quality, fish and wildlife. Drainage districts are intended to provide a special benefit to landowners; specifically, they afford a greater level of drainage and flood protection than the county provides. The drainage district might consider a flooded yard or pasture to be a problem, but the county may not consider it to be a problem from a public viewpoint. However, preventing road flooding to insure emergency vehicle access provides a public benefit that meets the county goals.

The county's flood protection program includes setting standards for new drainage systems. The ditch could be managed to provide the level of protection that is currently required of new drainage systems, or for some lower or greater level of protection. Current standards require that drainage ditches convey the 10-year storm, and culverts convey the 25-year storm. Within the Urban Growth Management Area, the standards limit road flooding from the 25-year event to no more than 25% of a travel lane. The county has no standards for improvements to existing drainage systems.

Funding. The drainage district has traditionally relied mainly on inexpensive hand-labor, and its current revenues are not sufficient to fund an expanded maintenance program. To increase revenues, the drainage district could expand its boundaries by any of three methods (RCW 85.06) and add lands that drain to the ditch and/or benefit from ditch maintenance. First, the boundaries could be expanded by the county commissioners upon petition by a majority of the affected landowners. Second, the drainage district could directly annex additional lands upon approval of a majority of landowners in the existing and proposed district. Third, the drainage district could petition the Superior Court to add new lands that benefit from the drainage district activities.

The county could support the district maintenance activities by providing additional stormwater rate discounts to drainage district ratepayers. The county could fund its own maintenance activities by increasing its standard stormwater utility-wide rates or setting a special stormwater utility rate for the land that contributes runoff to the ditch.

Assuring Access. The ditch can only be maintained if the group maintaining it has guaranteed access to the ditch. No recorded easements or rights-of-way along the Chambers Ditch have been located. The developer of the Wilderness subdivision signed an agreement with the Chambers Drainage District to provide the district with access to the ditch and to pay the drainage district's annual assessments, in return for the district maintaining the ditch.

The drainage district has the authority to acquire property or rights-of-way for necessary drainage both inside and outside its boundaries. The drainage district also has the right of eminent domain, both inside and outside its boundaries. The county has similar authorities.

Wetlands Regulations. The ditch traverses a few small wetland areas below Little Chambers Lake, and empties into a large wetland at the head of Chambers Creek. The local governments, state and federal governments all regulate land uses and activities in wetlands because of their critical role in cleaning and storing runoff and providing habitat for birds, fish and wildlife. Excavating in a wetland is a regulated activity.

The local wetland regulations permit active drainage districts to maintain their ditches, although the county requires drainage districts to develop their maintenance practices in consultation with county, state and federal agencies. The local regulations do not spell out what activities constitute ditch maintenance. Brushing and mowing would probably be allowed without review by most agencies. Excavating may require federal, state and local permits.

The local wetland regulations permit some maintenance of existing agricultural drainage ditches. Beyond the drainage district's boundaries, the ditch could be dug out through a wetland to the original specifications if the excavating constitutes agricultural ditch maintenance as part of existing and ongoing agricultural activities. Clearly, the ditch was constructed originally to provide agricultural drainage. However, most of the area has since been converted to residential development. County records indicate that the drainage district constructed the ditch only to Yelm Highway, although they have maintained it for another 800′ downstream. Ditch construction and maintenance beyond that point was probably done by private landowners. Current owners of agricultural lands below Yelm Highway reported that they have periodically maintained the ditch for several decades.

The U.S. Army Corps of Engineers and Department of Agriculture regulate the filling and excavating of wetlands. Federal regulations were revised in the 1980s to preserve remaining wetlands and halt the widespread practice of wetland filling and dredging, because much of the nation's wetlands have been destroyed and scientists and managers have realized the important functions of the remaining wetlands. Currently, most dredging is severely restricted and requires a federal permit.

The wetlands along Chambers Ditch lie on private property. The wetlands provide income and other benefits to the property owners, as well as public benefit. Property owners have contended in the courts that wetland regulations intended to protect the public benefits of wetlands have reduced their land's value, so they should be compensated. The courts have recently ruled that if regulations eliminate all economic uses of the land, the government may be obligated to compensate the landowner.

Besides the regulatory requirements, flood-protection effects of digging the ditch through a wetland must be weighed against the other environmental impacts. Digging a ditch through a wetland has the potential for draining the wetland and altering its hydrological and biological characteristics.

3) Expand the ditch capacity. The ditch could be widened and/or deepened to provide additional capacity. At the same time, the ditch could be reconfigured to provide shallower side slopes and a maintenance access road. Expanding the ditch capacity would present many of the same challenges as increasing the level of maintenance, discussed above.

The existing ditch has steep to overhanging, unvegetated sides and a flat, narrow bottom for much of its length. This results in sidewall erosion and bank sloughing. Current standards recommend designing open conveyances with broad, shallow-sloped sidewalls planted with grass. Recontouring would widen the ditch, which would require additional right-of-way in several locations.

The lack of an access road on the ditch makes maintenance difficult. An access road along one side of the ditch would allow a brush mower to be driven alongside the ditch, similar to the way the county currently maintains roadside ditches. The access road would also serve as additional flood plain for major flood flows. Constructing an access road would also require additional right-of-way. Ditch expansion would be expensive in the Wilderness subdivision, where much of the ditch has been armored.

These measures would provide both flooding and water quality benefits. Existing flooding from the 10-year and 100-year flows would be eliminated. Increased future 100-year flows would also be contained within the ditch and wetland. Broad, shallow-sloped grassy side walls would eliminate erosion that causes downstream sedimentation, and would provide water quality treatment through sediment removal and biological removal of nutrients.

Some short term loss of streamside fish habitat might occur because some vegetation would be removed to widen the ditch. The impact would be minimal because the ditch is dry for much of the year. This impact could be mitigated through replanting. Replanting would not prevent or reduce maintenance, because the access road would allow continued maintenance. Reduced erosion and sedimentation would benefit downstream fish habitat. Modeling indicates that expanding the ditch capacity would not increase downstream peak flows.

4) Detain stormwater runoff in Little Chambers Lake. Stormwater runoff which currently drains rapidly from Little Chambers Lake into the ditch could be detained in the lake and released more slowly to the ditch.

Little Chambers Lake could be used to store more stormwater, either by building a control structure on the lake to raise the lake level during storms, or by dredging the lake to increase its capacity. Dredging the lake would be dubious from an engineering standpoint, and would probably not be permitted by federal regulations because it would cause significant impacts to a large, high-quality wetland. In addition, the groundwater table controls the lake level, so dredging would probably not create much additional floodwater storage capacity.

An outlet control structure would reduce flooding in Chambers Ditch by raising the level of Little Chambers Lake during storm events, and allowing the lake to drain down slowly into the ditch. This option is technically feasible, but the high water would threaten septic systems and wells around the lake, which could create additional environmental impacts such as fecal coliform and nutrient contamination of the lake. The altered lake hydrology would also be likely to change the composition of the wetland vegetation.

This alternative would reduce flood flows in Chambers Ditch late in the year after the lake level has risen, but it would not reduce flooding from intense, early season storms before the lake has started draining to the ditch.

5) Detain stormwater runoff at other upstream locations. Stormwater runoff which currently discharges to the ditch from other upstream stormwater facilities could be further detained or infiltrated. This could be accomplished by repairing or expanding the existing facilities that discharge to the ditch, or by constructing new ones.

Engineering studies in other northern Thurston County basins have demonstrated that retrofitting new facilities in developed areas is expensive, largely because of the high cost of removing and rebuilding facilities in developed neighborhoods, and the high property value of developed areas (Entranco 1994). However, this option could be cost effective where the projects would also solve a local flooding or water quality problem.

There are approximately 80 stormwater facilities in Chambers basin, and field inspection has identified ten which drain to Chambers Ditch (mostly in the Wilderness area) and could be repaired or expanded. These facilities already have existing drainage easements, and some are in areas with localized flooding. Their capacity could be increased by about 5-30%. There may also be some undeveloped sites where new facilities could be installed to detain more runoff.

Adding more detention capacity would not significantly reduce flooding along the ditch without additional measures. The facility improvements would provide additional water quality treatment and reduce the water quality impacts to the ditch.

6) Educate homeowners on proper disposal of yard waste. The county or the drainage district could provide homeowners with information on how to properly dispose of yard waste. The ditch commissioners and several residents noted that yard waste dumped in the ditch was a major cause of clogged culverts.

Local agencies have already developed several informational materials and workshops on disposing yard wastes. For example, the county operates a composting facility at the Hawks Prairie landfill, and offers free monthly workshops on yard and kitchen waste composting.

These resources could be offered to homeowners who live along the ditch. Possible methods of disseminating information include neighborhood workshops, presentations at homeowner association meetings, direct mailings, and classroom presentations in local schools.

Educating homeowners could help prevent flooding due to clogged culverts and help reduce the cost and frequency of maintenance, and has the added benefit of helping extend the life of the county landfill by promoting home composting.

5.1.3 WIGGINS ROAD DITCH FLOODING

Wiggins Road ditch runs along the west side of Wiggins Road, and flows south from Morse-Merryman Road for 4,200′ to the outlet at Chambers Ditch about 600′ south of 43rd Avenue SE. The ditch passes through two culverts under public roads and nine culverts under private driveways south of Morse-Merryman Road, and discharges though a 260′ long pipe. The ditch is about 5′ deep by 4′ wide and runs very close to the edge of the road, with no shoulder between the ditch and the road.

Flooding has been reported periodically along Wiggins Ditch despite periodic maintenance, and flooding is projected to increase as the basin develops. Future flooding is expected to be significant primarily from the larger storm events.

The flooding analysis for Wiggins Road was performed in the same way as the Chambers Ditch analysis: the existing and future flows were predicted and calibrated with the HSPF model, the ditch was surveyed, and the flows were analyzed for flooding impacts with the HEC-2 model. This analysis assumed that the ditch was maintained. The following table summarizes the results.

Table 5-1 Existing and future flooding on Wiggins Road ditch

Storm event	Length of flooded roadway (feet)	
	Existing conditions	Future conditions
10-year	1,000′	1,000′
25-year	1,200′	1,600′
100-year	1,600′	3,175′

The modeling indicated that flooding was caused primarily by inadequate culvert capacity, rather than inadequate ditch capacity. The culvert diameters vary widely at different locations along the ditch, and the smallest is only 1′ in diameter.

Discussion and Analysis of Alternatives

Alternatives for reducing flooding along the ditch include:
1) Install trash racks on culverts
2) Expand the culvert capacity
3) Replace the ditch with a piped system
4) Detain stormwater runoff upstream
5) Increase ditch maintenance

Each of these measures could be implemented separately or in combination with others.

1) Install trash racks on culverts. Trash racks could be installed on culverts under road crossings, to prevent large debris from clogging the culverts and causing roads and driveways to flood. They would not prevent accumulation of smaller debris, and they could increase clogging if not cleaned regularly, which would require increased maintenance frequency. When residents report flooded roads due to clogged culverts, county crews must remove debris from the culverts. Regularly maintained trash racks might reduce the frequency of these emergency call-outs, but they could also interfere with the crews' ability to use maintenance equipment in the culverts.

Most flooding on Wiggins ditch occurs because the existing culverts are too small and constrict flow, not because they clog up. Trash racks would not reduce flooding from inadequate culvert capacity. They would not have any significant environmental impacts.

2) Expand the culvert capacity. The under-sized culverts under public road and private driveway crossings could be replaced with larger culverts. Trash racks could be installed at the same time. The size of the culvert replacements would determine the level of flood protection provided. The table below summarizes the culvert replacement options to provide 25-year and 100-year protection. The 25-year event is the county standard for road flooding within the UGMA.

Table 5-2 Wiggins Road culvert replacement alternatives

EXISTING CULVERT			NEW CULVERT DIAMETER (ft)	
Station[1]	Diameter (ft)	Length (ft)	25-year storm	100-year storm
2+50	2.5	260	2.5	3
18+80	3	20	3	4
26+45	1.5	40	3	4
28+90	1.5	30	3	3
36+20	1	570	3	3
42+10	1.5	45	2	3

[1] Station locations refer to hundreds+tens of feet from the confluence of Wiggins and Chambers ditches

If the 25-year culverts were installed, all flooding would be eliminated from the 25-year event, and flooding would be reduced but not eliminated from the 100-year event. Under this option, about 600′ of roadway at three locations would remain prone to flooding from the 100-year event. If the larger culverts were installed, all flooding from the 100-year event would be eliminated.

Enlarging the culverts would slightly increase the velocity of water draining into Chambers Ditch downstream. Increased velocity has the potential to accelerate erosion at the point of discharge. However, analysis of the flow velocities indicates that erosion would not be a problem because the gradient is so flat that the velocities would remain fairly slow. When the basin is fully developed in the future, the 100-year event will create an average velocity of only 2 feet per second at the outfall of Wiggins ditch.

Enlarging the culverts could slightly increase the peak flow of runoff draining into Chambers Ditch downstream. The impacts of future development on peak stream flows are described in greater detail later in this chapter. Increases in downstream peak flows are predicted to be insignificant.

Enlarging the culverts will not have a significant impact on water quality, because the runoff velocity will not increase substantially enough to reduce the ditch's ability to settle out sediments.

3) Replace the ditch with a piped system. The entire ditch could be replaced with a piped system for draining road runoff. A piped system would completely eliminate flooding along Wiggins Road.

Piped systems are the least desirable alternative for runoff conveyance under Thurston County's current design standards for new drainage systems. Open conveyances are preferred because they provide better water quality treatment and they are cheaper and easier to install. Vegetation and surface roughness in a ditch or swale help to slow down the runoff velocity and settle out sediments which damage fish habitat and usually contain toxic heavy metals and hydrocarbons. Vegetation also biologically removes several types of pollutants. However, Wiggins ditch is largely unvegetated. Water quality of the runoff discharging from Wiggins ditch might decline slightly if the ditch were replaced by a piped system.

The velocity of runoff discharged from a piped system has not been modeled. Piped systems typically create significantly higher velocities than ditches, but in such a low-gradient setting the velocities might still be too low to cause erosion. The banks of Chambers Ditch could be fortified at the discharge point, if necessary.

A piped system would not increase peak flows downstream in Chambers Ditch significantly compared to the existing system. The impacts of increased peak flows described later in this chapter apply equally well to both drainage systems, and are not predicted to be significant for the reasons described above.

4) Detain stormwater runoff upstream. Stormwater runoff which currently drains into Wiggins ditch could be detained farther upstream and released more slowly to the ditch. This could be accomplished by detaining stormwater in wetlands that drain to the ditch, or by diverting runoff that currently drains into the ditch into new detention ponds.

Two lateral ditches connect a large wetland west of Wiggins Road to Wiggins ditch. A control structure could be installed on the lateral ditches that would back runoff up into the wetland during major storms, and allow it to drain off slowly into the ditch. Berms might need to be constructed around the wetland to contain the runoff.

Storing runoff in the wetland would help reduce flooding along the ditch. The effectiveness of this solution would depend on the amount of stormwater that could be stored in the wetland, and the rate at which it could be released to the ditch. This alternative has not been analyzed hydrologically. The wetland is about 38 acres, so if one foot of water was backed up into it, the wetland would provide about 38 acre-feet of storage.

This alternative would provide additional water quality treatment by retaining stormwater in a wetland, which would provide natural treatment and allow sediment to settle out. However, most of the stormwater detained in the wetland would be relatively clean, direct precipitation rather than contaminated road runoff, so the water quality benefits to Wiggins ditch and the water quality impacts to the wetlands would be minimal.

Storing water in the wetland would alter the wetland's hydrology and could change its vegetation composition and wildlife habitat. These impacts are difficult to quantify and would depend largely on the degree and duration of inundation. Plant species that tolerate more frequent inundation might tend to increase. However, the wetland is in a highly disturbed area, so that species adapted to altered hydrology may already predominate. The altered hydrology could also affect the wetland's amphibian species. In general, the wetland's water quality and stormwater values would increase, and would have to be evaluated against the vegetation and habitat values.

5) Increase ditch maintenance. Ditch maintenance could be increased to include more frequent inspection and cleaning. The ditch is currently maintained by Olympia and county road maintenance crews.

The flooding analysis assumed that the ditch is being maintained, because the ditch is already included in the jurisdictions' scheduled maintenance program. However, field observations and reports from residents confirm that the ditch floods occasionally due to debris that causes blockages. More frequent inspection and maintenance would probably reduce the frequency of this type of flooding. Increased maintenance would not reduce any of the modeled flooding problems which assumed that the ditch is maintained.

Increased maintenance would probably have little or no impact on water quality because the ditch already has little existing vegetation and consequently provides little water quality treatment. Fish habitat would not be affected because the ditch is rarely used by fish.

5.1.3 BOULEVARD ROAD/WILDERNESS/NEWCASTLE POND FLOODING

Boulevard Road, a major arterial, floods frequently when the Wilderness subdivision pond overflows. The Wilderness pond is located in a pothole on the east side of Boulevard, south of Wilderness Drive. The county cleaned out, repaired and enlarged the pond two years ago. A smaller pothole west of Boulevard Road, across from the Wilderness pond, was recently purchased jointly by Thurston County and Olympia for additional stormwater detention capacity.

The Newcastle subdivision lies just north of Wilderness on Boulevard road. Runoff from the Newcastle pond overflows into the Boulevard Road ditch and flows south through a culvert under Wilderness Drive, into the Wilderness pond. The ditch is too small, so the runoff floods Boulevard Road and Wilderness Drive during heavy rains. The ditch also erodes and deposits sediments that clog the Wilderness Pond. The county cleaned the sediment out of the pond in 1992.

Discussion and analysis of alternatives

Alternatives for reducing flooding on Boulevard Road include:
1) Enlarge the capacity of the Wilderness pond.
2) Drain excess runoff to the pothole west of Boulevard Road.
3) Detain stormwater runoff upstream.
4) Stabilize eroding ditches that drain to the Wilderness pond.
5) Enlarge the culvert under Wilderness Drive at Boulevard Road.

Each of these measures could be implemented separately or in combination with others.

1) Enlarge the capacity of the Wilderness pond. The Wilderness pond could be enlarged to store additional runoff. The pond could potentially be enlarged from 188,000 cubic feet to 399,000 cubic feet, without deepening it. Enlarging the pond more than that would require purchasing adjacent property which is currently slated for development.

Enlarging the pond would help reduce the water level during smaller storm events, but the pond would still overflow onto Boulevard Road during the 2-year and greater storms under existing conditions.

Pond enlargement would be limited by the depth of the ground water table. The soils are saturated at a depth of 3′ below the existing pond bottom. If the pond were deepened too far, the risk of groundwater contamination would increase. Local drainage regulations require preserving at least 3′ of dry soil between the ground water table and the bottom of the pond to reduce the risk of ground water contamination. Enlarging the pond would not affect surface water quality or habitat.

2) Drain excess runoff to the pothole west of Boulevard Road. Excess runoff from the Wilderness pond could be drained through a culvert under Boulevard Road, into the smaller pothole on the west side of the road. This would provide an additional 171,000 cubic feet of storage.

Thurston County recently purchased this pothole. The pothole could be enlarged without deepening, and used to infiltrate the excess runoff from Wilderness and Boulevard Road. The county and Olympia are currently negotiating for an agreement to share the cost of this project.

The pothole west of Boulevard Road, combined with the enlarged Wilderness Pond, would provide about 570,000 of the 600,000 cubic feet of stormwater storage required to prevent flooding from the 100-year storm now and in the future, as long as new developments upstream of Newcastle do not contribute more runoff to the ponds. The ponds would accept a small amount of additional runoff from the few undeveloped lots in the Wilderness/Newcastle area.

The project would have no impact on water quality or fish habitat.

3) Detain stormwater runoff upstream. Stormwater could be detained upstream from the Wilderness pond, which would reduce flows into the pond and help to alleviate flooding of Boulevard Road.

The area tributary to the Wilderness pond is mostly developed, leaving few sites available for new stormwater detention facilities. One potential stormwater pond site exists on vacant land south of Limerick Street, off Wilderness Drive. Runoff draining down Highline Drive and Limerick Street that currently drains to the Wilderness pond could be diverted to a new pond.

The new pond would have little effect by itself on Boulevard Road flooding. Combined with the other alternatives described above, it would reduce the needed capacity of the Boulevard Road ponds by 36,000 cubic feet, which would be enough to prevent flooding from the 100-year storm. The pond would also reduce a local flooding problem (see 5.1.5 below).

This project would have no impact on water quality or fish habitat.

4) Stabilize eroding ditches that drain to the Wilderness pond. The eroding ditches along Boulevard Road that drain to the Wilderness pond could be piped or stabilized with riprap or geotextile materials (fabrics designed to prevent erosion).

Dry season soil tests indicated that the soil infiltration rates in the bottom of the Wilderness pond vary widely, but the worst soils infiltrate at a rate of 0.2-0.6" per hour. Inspection in 1992 revealed that the bottom of the pond had become clogged with fine sediments from the eroding ditches on Boulevard Road, severely restricting infiltration. The sediments were cleaned out at that time and infiltration was restored, but the ditches continue to erode and deposit sediment in the pond.

Stabilizing the eroding ditches would help prevent the Wilderness pond from clogging up and causing flooding, and would reduce the need for frequent maintenance. Flooding would be less frequent, but the Wilderness pond alone would still be inadequate for the 100-year storm.

Stabilizing the ditch would improve water quality by reducing total suspended sediments and turbidity in the runoff and by preventing road flooding which adds to contamination. The project would have no impact on fish habitat.

5) Enlarge the culvert under Wilderness Drive at Boulevard Road. The culvert under Wilderness Drive at Boulevard Road, which carries overflows from the Newcastle pond to the Wilderness pond, could be replaced with a larger culvert.

The existing culvert under Wilderness Road becomes clogged easily because it is too small. When the culvert clogs, runoff floods Boulevard Road. A larger culvert with a trash rack would reduce floods from clogging and reduce the need for frequent maintenance. The culvert would have no impact on flooding caused by inadequate pond size, which is a larger problem. The project would have no impact on water quality or fish habitat.

5.1.4 Wilderness Court/Highline Drive/Wilderness Drive Flooding

Dry wells have failed at several places on Wilderness Drive, Highline Drive and Wilderness Court. Runoff draining down Highline Drive floods across Wilderness Drive onto Wilderness Loop. Runoff from Wilderness Court runs into a ditch, flows west along Wilderness Drive and contributes to the flooding of the Wilderness pond described above. The county maintenance crews installed an additional dry well in the low spot on Wilderness Drive about 5 years ago, but it has failed to prevent flooding, due to poor soil. The only remaining alternatives include reducing runoff entering the system by routing all roofs and driveways to on-site infiltration trenches, or routing the system elsewhere.

The runoff could be routed to a new stormwater pond in the vacant community open space land south of Limerick Street. The pond would provide up to 47,000 cubic feet of storage. This would eliminate the road flooding and reduce the flow into the Wilderness pond, which would reduce the needed capacity of the Wilderness pond (see 5.1.3 above).

5.1.5 Local Flooding Problems Near Chambers Ditch

The following sites have experienced chronic flooding and discharge or overflow to Chambers Ditch:

- 60th Loop

- Donnelly Drive
- Glenmore area
- Rainbow Lane
- 42nd Avenue
- Ferndale Court

These sites are in older subdivisions, constructed before the county had any drainage standards. Their stormwater facilities flood frequently, blocking roads and running overland into the ditch. Alternative solutions include installing additional dry wells or infiltration facilities, enlarging existing ponds or building new ponds.

Five of the sites have stormwater ponds that could be enlarged. Some have failing dry wells or infiltration facilities. The facilities could be rebuilt or enlarged. Initial estimates indicate that the capacity of these facilities could be increased by 5-30%. They already have existing drainage easements. One site has land available for a new pond.

These projects would reduce the local flooding problems. The projects would improve water quality by preventing untreated runoff from washing directly into Chambers Ditch, which would also benefit downstream fish habitat.

5.1.6 FUTURE FLOODING IN SOUTH CHAMBERS BASIN

The hydrologic modeling indicated that future development would not cause flooding or peak flow problems on the South Tributary, which drains the southern half of Chambers basin. However, the model calibration for the south basin was based on flow monitoring for only one location on the South Tributary. The calibration report noted that the modeling results could not be verified reliably without additional data.

Additional continuous flow gauging stations could be installed in the south basin. At least two years of data collection would be required to provide sufficient information to verify the model calibration. The model could be updated and the future growth scenario could be remodeled in order to insure that future development does not cause flooding problems in the south basin.

5.2 WATER QUALITY PROBLEMS

The water quality assessment performed for this basin plan identified several specific water quality problems. Chapter 4 summarized the overall water quality conditions in the basin. This section describes the specific problem sites.

The major water quality problems in the basin include fecal coliform contamination of stormwater in the ditches and Chambers Creek, heavy metals in stormwater sediments and lake sediments, and nutrients in Ward and Hewitt Lakes. These are all nonpoint sources of pollution. Map 14 shows the location of stormwater outfalls in the basin that discharge directly to surface water.

5.2.1 Chambers Ditch at Herman Road (CK10) and Herman Road Ditch at NE (SCH1)

Water quality sampling of Chambers Ditch at Herman Road (CK10) identified the following problems:

- Fecal coliform bacteria levels failed the second part of water quality standard and had the highest loading of the sampling sites.
- Dissolved oxygen levels fell below water quality standard in March, April, May and June due to high temperatures and low flows.
- Total Phosphorus in the June sample exceeded the EPA maximum recommendation for preventing nuisance weed growth.
- The site had the highest turbidity levels in Chambers Ditch.
- The farm site through which Chambers Ditch flows immediately above this location had cattle which may have contributed bacteria to the ditch.

Stormwater and sediment sampling of the roadside ditch draining into Chambers Ditch at Herman Road (SCH1) identified the following problems:

- Fecal Coliform bacteria levels failed both parts of the water quality standard.
- High turbidity and TSS in the Herman Road ditch contributed to the turbidity problem in Chambers Ditch cited above.
- Nutrient levels were moderately high.
- Chromium, copper, nickel, zinc in sediments slightly exceeded comparison criteria.
- Samples contained 9 organic contaminants in fairly low concentrations compared to criteria.

Discussion and analysis of alternatives

Nutrients, sediments and fecal coliform contamination are the top priority concerns at this site. Nutrients and sediment could cause ongoing problems by causing the ditch to clog up with weed growth and increase the need for maintenance to prevent flooding. While fecal coliform concentrations do not appear extreme, the high resulting loadings in the ditch (10.1 billion per day) could present a health hazard further downstream where the ditch passes through residential neighborhoods. Low dissolved oxygen levels result naturally from dwindling flows in the late spring, and metal levels were only slightly elevated.

Runoff in Chambers Ditch at this site comes only from Chambers and Little Chambers Lakes and from a farm between the lake and Herman Road. Runoff in the Herman Road ditch includes road runoff and drainage from homes east of Chambers Ditch. The nutrients and fecal coliform could come from faulty septic systems, agricultural practices, and/or natural wetland conditions. Sediments probably come from agricultural practices. Potential solutions include: conservation planning for farms, geese controls, septic system monitoring and repair, homeowner education programs, stream side revegetation, and stormwater treatment facilities.

Conservation Planning For Farms. Farm animals along the ditch are one likely source of fecal coliform contamination and suspended sediments in Chambers Ditch. Conservation planning by the Conservation District for farms along the ditch would help identify specific practices that contribute pollution, and develop improved farm management measures (called "Best Management Practices" or BMPs). One possible BMP would be fencing to prevent farm animals from directly accessing the ditch. However, this does not explain the source of fecal coliform contamination in the roadside ditch on Herman Road.

Phosphorous levels in the upper ditch are probably closely tied to phosphorus levels in Little Chambers Lake, which fluctuate radically due to the natural nutrient cycling of aquatic vegetation in the lake. Phosphorus contamination may also result from fertilizer application on the farm site, and could be minimized by implementing a farm plan that includes a strategy for application times and rates.

Geese Controls. Resident geese and waterfowl in and around Chambers and Little Chambers Lakes could also be a source of fecal coliform. The US Department of Agriculture Animal Damage Control Program has developed several methods for reducing goose populations, which range from simple and relatively ineffective to complicated and expensive. The simplest techniques involve noise makers to frighten away geese. A technique for preventing eggs from hatching is being tested around Lake Washington. The most effective long-term solutions involve changing the vegetation around the lake to discourage waterfowl and discouraging people from feeding the geese.

Septic System Monitoring & Repair. A septic system survey of the mobile home park on Herman Road would help determine if failing septic systems there are contributing to the problem. Homeowner education programs on septic system maintenance could help prevent system failures in the future. Owners of failing septic systems would be eligible for low-interest loans to repair their systems.

Homeowner Education. Nutrient contamination could come from common household practices such as yard maintenance. Homeowner education on septic system maintenance, lawn care, and least toxic household products would help to prevent water quality degradation from household practices. Informational materials could be provided to new homeowners at the time of purchase.

Streamside Revegetation. Dissolved oxygen levels are probably naturally low through this segment of the ditch because the land is so flat and open that low gradient and high temperatures encourage low oxygen levels. Planting additional canopy cover along the ditch would lower the water temperatures, but it is probably unnecessary. The temperatures do not cause a downstream problem because groundwater inputs lower the water temperatures downstream, and fish do not utilize the section of the ditch with high temperatures. Also the ditch is dry for most of the year.

Stormwater Treatment. The roadside ditch contributes fecal coliform, nutrients and total suspended solids that cause high turbidity in Chambers Ditch. Stormwater wet ponds and constructed wetlands have high potential for removing suspended solids and moderate-to-high potential for reducing phosphorous (Horner et al 1994). Treatment practices vary widely in their ability to remove bacteria.

A treatment facility could be constructed for the roadside ditch, east of Chambers Ditch. A wet pond or artificial wetland could be highly effective at removing sediments from the runoff, and could also help to reduce the high nutrient levels in the runoff. An extended detention wet pond could be expected to remove 50-100% of total suspended sediments, 50-80% of total phosphorous, and 55% of total nitrogen (U.S. EPA 1993).

A treatment facility would be sized to treat the smaller, more frequent storms which cause the majority of water quality impacts. The facility would be too small to detain large storm runoff, so it would have no impact on downstream flooding of the ditch. Water quality treatment would benefit downstream fish habitat.

5.2.2 Roadside Ditch at Wiggins Road (SCH2)

Stormwater and sediment sampling of the Wiggins Road ditch, draining into Chambers Ditch, identified the following problems:

- Fecal coliform bacteria levels failed the second part of the water quality standard.
- The highest flows of all stations monitored were recorded here.
- Nitrate+nitrite levels were very high during one storm.
- Nickel in sediments exceeded comparison criteria
- Sediments contained 12 (most of all) organic contaminants in high concentrations.

Discussion and analysis of alternatives

The high nitrate+nitrite level measured in January could be caused by inadequate agricultural practices at the farms in the tributary area. Fecal coliform concentrations exceeded standards and loading levels were very high (2.35 billion per day), contributing significantly to the bacteria loading levels in Chambers Ditch. The main organic contaminants in the stormwater sediments were PAHs, which come from vehicle emissions. The concentrations for those few contaminants for which criteria have been developed appear to be below the levels that cause biological effects. However, there is little agreement on accurate effects criteria for PAHs. Furthermore, PAHs are very persistent, which means they accumulate over time, and many PAHs are highly toxic to aquatic life.

The area contributing to the Wiggins Road ditch contains fairly low-density development with several small farms. Alternative solutions include: conservation planning for farms, homeowner education, increased stormwater maintenance, and stormwater treatment facilities.

Conservation Planning For Farms. The small farms are likely to be the source of fecal coliform contamination because there are no major developments along the ditch. Farm practices which could contribute fecal coliform include unrestricted use of the ditch by animals, and manure application and management. Conservation planning for farms would identify BMPs to reduce these sources of contamination. Runoff event monitoring would help to indicate the effectiveness of conservation planning measures.

Homeowner Education. Volatile organic compounds rarely exist in the natural environment; they almost always result from human practices but they are difficult or impossible to trace to a source. Polyaromatic hydrocarbons (PAHs) come from vehicle amazons and pthalates are found in numerous common household products including solvents, detergents, dyes, lubricants, photographs, plastics, rubber, packaging and cosmetics. Homeowner education on least-toxic household products could help reduce the level of PAHs and pthalates that end up in runoff. Educational materials distributed at points-of-purchase such as retail stores in the basin could reach wider audiences.

Increased stormwater maintenance. Frequent removal of sediment from catch basins and ditches could prevent contaminated sediments from reaching streams. Shallow grass-lined ditches would perform best at trapping sediments, but there is little room for swales along Wiggins Road.

Stormwater Treatment. A stormwater pond could remove most of the suspended sediments (which contain volatile organics), if it was large enough to handle the large volume of stormwater flow in Wiggins ditch. Treatment facility are normally sized to treat the 6-month storm events which cause the majority of water quality impacts. The facility would not be intended to detain runoff from larger storms, so it would not help prevent downstream flooding of the ditch.

A vegetated swale along the roadside would provide more water quality treatment than the existing ditch. Unfortunately, the road right-of-way is too small to accommodate a swale that could convey all the runoff. A swale would require substantially more right-of-way.

5.2.3 Ditch off Ferndale within Wilderness (SCH3)

Stormwater and sediment sampling of the ditch off Ferndale that drains to Chambers Ditch identified the following problems:

- Stormwater failed both parts of the fecal coliform water quality standard, and had the second highest recorded concentration of fecal coliform.
- Nitrate+nitrite levels were high during one storm and phosphorous levels were moderately high during another storm.
- Nickel in sediments exceeded comparison criteria, but was similar to the nickel in sediment samples from other sites.
- Sediments contained 5 organic contaminants.

Discussion and analysis of alternatives

This location had the highest fecal coliform loading level (6.28 billion per day) of all the stormwater outfalls sampled. The entire Wilderness subdivision relies on individual septic systems, which are the likeliest source of fecal coliform contamination and high nutrient levels at this site. Pet waste is another possible source. Alternative solutions include: monitoring and repair of failing septic systems, homeowner education, and converting to sewer service.

Septic System Maintenance & Repair. A house-to-house septic system survey, beginning with the houses closest to Chambers Ditch and its feeders, would identify the failing septic systems. Thurston County's septic system survey methodology is considered to be a national model. Homes with failing systems would be eligible for low-interest loans to repair their systems.

Homeowner Education. Thurston County has a proven education program that relies on small neighborhood meetings to provide hands-on training for septic system maintenance. Homeowner education would help prevent additional system failures in the future.

Sewer Service. Alternatively, the subdivision could be connected to the sewer system. Wilderness lies within the Urban Growth Management Area, so it is eligible to receive sewer service. The sewer main would have to be extended up Wilderness Drive from the existing line at Boulevard Road. About 230 individual houses would have to abandon their septic systems and connect to the sewer line. Sewer service would help to eliminate fecal coliform contamination of Chambers Ditch from septic systems at this location.

5.2.4 Chambers Ditch at Yelm Highway (CK11)

Water quality sampling of Chambers Ditch at Yelm Highway identified the following problems:

- Fecal coliform failed the second part of the water quality standard, and was the third highest of all sites sampled.

- Nitrate+nitrite loading was the second highest of all sites sampled.
- TSS loading was the highest of all sites sampled.
- The stream banks upstream have unrestricted access by farm animals.
- Ammonia levels were high in one sample.

Discussion and analysis of alternatives

The area above Yelm Highway contains agricultural lands and residential developments. Alternative solutions include: conservation planning for farms, homeowner education, and stream bank revegetation.

Conservation Planning For Farms. The pasture just above Yelm Highway was being used by farm animals when the water quality monitoring was conducted. Conservation planning for farms would identify BMPs which could reduce contamination from agricultural activities. Additional storm event monitoring would help determine the effectiveness of conservation planning measures.

Farm animals along the ditch were probably responsible for the high fecal coliform, ammonia, and nitrate+nitrite levels at this site. Farm animals might also have caused the high level of total suspended solids, by trampling down the banks and disturbing the bed of the ditch. The ditch could be fenced to prevent future access by animals. Bank erosion from other causes could also be contributing sediments to the ditch.

Homeowner Education. Nutrient contamination could originate from common household practices such as yard maintenance. Homeowner education on septic system maintenance, lawn care, and least toxic household products would also help to prevent impacts from the future development. Informational materials could be provided to new homeowners at the time of purchase.

Streambank Revegetation. A reconnaissance survey would identify any erosion problem sites, which could then be revegetated to reduce downstream sedimentation. Revegetation would also benefit water quality by removing nutrients from runoff, and would provide additional habitat.

5.2.5 Yelm Highway Southwest Storm Drain (SCH4)

The stormwater on the southwest side of Yelm Highway and Chambers Ditch was not sampled because the drain outlet was not running during any of the field visits. Sediment sampling of the storm drain identified the following problems:

- Nickel in sediments exceeded comparison criteria but was similar to concentrations at other stations.
- Zinc in sediments exceeded comparison criteria.

- Six organic contaminants were found in sediments.

Discussion and analysis of alternatives

The degree to which contaminated sediments pose a threat to Chambers Ditch could not be determined since the stormwater system remained dry during the sampling periods. The sediments would only threaten the ditch if stormwater runoff transported them into the ditch. Periodic removal of sediments from the catch basins would prevent this from becoming a problem, as well as helping extend the life of the infiltration system. Additional stormwater event monitoring would help determine if stormwater causes other problems here.

5.2.6 WILDERNESS DRIVE STORMWATER DISCHARGE TO WILDERNESS POND (SP1)

Stormwater sampling of the stormwater outfall from Wilderness Drive that discharges to the detention pond at the corner of Wilderness Road identified the following problems:

- Runoff failed both parts of the fecal coliform water quality standard.
- Samples contained the highest ammonia, total phosphorus, total suspended solids and turbidity of all stormwater sampled.

Discussion and analysis of alternatives

Stormwater from this outfall originates in the Wilderness subdivision. Alternatives include: septic system monitoring and repair, connection to sewer service, and homeowner education.

Stormwater at this location does not threaten any surface water bodies because the pond is in a closed depression that drains to groundwater. Three feet of soil separate the pond from the groundwater table, which might provide sufficient treatment. The fecal coliform contamination could represent a public health threat, but the pond is steep and surrounded by a chain link fence, so access is difficult.

Failing septic systems are the likeliest source of contamination at this site. The house-to-house on-site septic survey described in section 5.2.3 above would help to alleviate this problem. Homeowner education on proper septic system maintenance could also help prevent septic systems from failing and leaking into the stormwater system.

5.2.7 CHAMBERS CREEK AT RICH ROAD (CK12)

Water quality sampling of Chambers Creek at Rich Road identified the following problems:

- Fecal coliform failed the second part of the water quality standards, and constituted the fourth highest loading source.

- Phosphorus concentration were above the EPA recommended levels in the summer, and constituted the third highest total phosphorus loading source.
- Dissolved oxygen levels failed the water quality standard.

Discussion and analysis of alternatives

Fecal coliform and nutrients are the main concern at this site. The dissolved oxygen levels were probably a natural result of the wetlands and the ditch flow slowing down and drying up in the spring. The land draining to Chambers Creek at Rich Road consists of a few scattered houses, the small Del Ridge development at 60th Loop, agricultural lands and an extensive wetland. Alternative solutions include: septic system monitoring and repair, homeowner education, and conservation planning for farms.

Failing septic systems and agricultural practices are potential source of fecal coliform and phosphorous contamination at this site. A septic system survey of the houses on 60th Loop and 59th Court would identify any failing septic systems. Homes with failing systems would be eligible for low-interest loans to repair their systems. Homeowner education would help prevent additional system failures in the future. Conservation planning for farms would help reduce contamination from agricultural practices. These alternatives are described in greater detail earlier in the chapter. Additional storm event monitoring would help determine the effect of these actions.

The wetland above Rich Road could be contributing fecal coliform from water fowl. The wetland also probably contributes phosphorous due to the natural nutrient cycling of the aquatic vegetation. Decaying plant materials also deplete dissolved oxygen. These natural processes cannot be controlled and are largely offset by downstream groundwater inputs.

5.2.8 Chambers Creek Mouth (CK14)

Water quality sampling at the mouth of Chambers Creek identified the following problems:

- Fecal coliform failed both parts of the water quality standard, and constituted the second highest loading of all creek stations.
- Nitrate+nitrite average levels and loading were the highest of all stations, and were higher than typical concentrations in unimpacted streams.
- Total phosphorus loading was the second highest of all stations.
- TSS loading was the second highest of all stations.

Discussion and analysis of alternatives

Creek mouths frequently exhibit high loading levels of pollutants because they receive contamination from all upstream sources. The land draining to the mouth of Chambers Creek includes several residential developments along the hill slope north of the creek and south of

Yelm Highway, as well as open space and agricultural lands in the floodplain near the creek. Alternative solutions include: septic system monitoring and repair and homeowner education.

Failing septic systems could be causing the elevated fecal coliform and nitrate+nitrite levels. A septic system survey of the houses in the up-slope development would identify any failing septic systems. Homes with failing systems would be eligible for low-interest loans to repair their systems. Homeowner education would help prevent additional system failures in the future. A conservation plan for the farm next to the creek could help prevent contamination from agricultural practices. These alternatives are described in more detail earlier in the chapter.

Additional stormwater event monitoring would help to trace other sources of contamination at the mouth station.

5.2.9 South Tributary (CK13)

Water quality sampling on the South Tributary east of Rich Road identified the following problems:

- Low pH and high ammonia concentrations, conductivity and nitrate+nitrite in November indicated an unusual event upstream.

Discussion and analysis of alternatives

Contamination at this site probably resulted from a one-time occurrence. Additional monitoring would be required to determine if the contamination is an ongoing problem here. The tributary was only sampled at one location, but the drainage includes almost half of the basin. Sparse land uses, extensive wetlands and the intermittent nature of the tributary would make source tracking difficult in this area.

5.2.10 Little Chambers and Chambers Lakes

Sampling of stormwater discharges into the lakes, sediments from the stormwater systems, and sediments from the lake bottom identified the following problems:

- Stormwater is discharged directly into lakes (see map 14).
- Both lakes have high aquatic weed growth.
- Both lakes have high sedimentation rates, and the sediments contain arsenic, cadmium, copper, lead, mercury, nickel, selenium and zinc in excess of comparison criteria.
- Chambers Lake contained the highest concentrations of arsenic, lead, mercury and zinc of all the lakes' sediments.

Stormwater sampling conducted by the city of Lacey identified several problem stormwater discharges:

14th Avenue SE. Stormwater from the outfall adjacent to the public fishing access at the north end of Chambers Lake (called "S1" in Lacey's study) exhibited high nutrient, fecal coliform and sediment loading, and was rated the top priority for remedial action.

Chambers Lake Drive & Marina Way. Stormwater from the outfall on Chambers Lake Drive near Marina Way on the north side of Little Chambers Lake (S5) exhibited high nutrient, fecal coliform and sediment loading, and was rated a high priority for remedial action.

26th Loop SE. Stormwater from the outfall on 26th Loop at the northeast corner of Little Chambers Lake (S7) exhibited high nutrient, fecal coliform and sediment loading, and was rated a high priority for remedial action.

West Lake Street. Stormwater from the outfall on West Lake Street on the east side of Chambers Lake (S2) exhibited high fat, oil and grease concentrations on one occasion, and moderate nitrate+nitrite levels.

Golf Club Road. Stormwater from the outfall at the end of Golf Club Road on the north side of Little Chambers Lake (S6) exhibited high fecal coliform levels.

Discussion and analysis of alternatives

Management recommendations for Chambers and Little Chambers Lakes will depend largely on the goals and intended uses of the lakes. Most lakes in the urbanizing areas of the county are managed for recreational uses, especially swimming, waterskiing, power boating and fishing. Other lake uses and functions include wildlife habitat, education, stormwater detention, and water quality treatment. Each lake use or function requires certain conditions.

Chambers and Little Chambers Lakes are shallow, eutrophic lakes which have changed markedly over the past 100 years. Old surveys indicate that most of the wetland area around the lake's northwest lobe were part of the open lake in the mid-1800s (U.S. Department of the Interior 1853). The lakes have aged and are steadily becoming shallower and more vegetated. Urban development has caused more nutrients to drain into the lake and accelerated eutrophication.

Management actions cannot reverse this natural process. Even dredging the lake would only temporarily reverse the trend, and dredging could have severe water quality impacts by stirring up the metal and nutrient laden sediments in the lake bottom. Chambers and Little Chambers

Lakes will probably never be good for swimming, power boating or water skiing because they are too shallow, murky and vegetated.

Chambers and Little Chambers Lakes are productive, nevertheless. They provide habitat for large mouth bass and other warm water fish species. They offer habitat for water fowl and other wildlife, and will become even more significant for wildlife as the surrounding areas develop. Olympia's wildlife habitat study identified areas around Chambers Lake as some of the best remaining habitat in the urban area. The lakes can accommodate a variety of low-impact recreational uses such as bird-watching, canoeing, electric motoring, and environmental education. The lakes are also important for stormwater detention and mitigation of downstream flooding. These activities form the basis for the alternatives evaluated below, which include: elimination of direct stormwater discharges, treatment of stormwater discharges, and homeowner education.

Elimination of Discharges. Several stormwater outfalls discharge to the lakes. Ideally, the discharges could be eliminated by developing infiltration facilities for the developments that drain to the lakes, and by reducing the impervious areas that cause stormwater runoff. Realistically, the discharges could not be eliminated completely because the ground water table in the sub-basin around the lakes is too high to accommodate much infiltration. Nevertheless, reduction of runoff at the sources would be most effective at reducing stormwater-related contamination of the lakes.

Stormwater Treatment. Eutrophication cannot be reversed, but the unnatural acceleration could be reduced. Nutrient loading comes from direct stormwater discharges and from landscape care practices. Stormwater discharges could be treated prior to discharge. Lacey has begun to develop stormwater treatment facilities for the highest priority outfalls identified in the *Chambers Lake Stormwater Management Plan* (1992).

Wet ponds and constructed wetlands can remove 50-80% amounts of nutrients from runoff (U.S.EPA 1993). Constructed wetland systems could be incorporated with trails, parks or interpretive facilities to provide additional recreational and educational values. Settling basins and filtration systems have high potential to remove suspended sediments (Horner et al 1994). Cleaning and maintenance of the stormwater systems could also be increased.

Homeowner Education. Homeowner education could reduce the level of nutrients from landscape maintenance activities. The Common Sense Gardening program offers homeowners alternatives to chemical fertilizers that solubilize readily into ground and surface water. The Operation Water Works program reaches commercial landscape contractors with similar information. These programs could be targeted at subdivisions around the lakes.

The Lacey stormwater study proposed several management recommendations for each of the stormwater outfalls, which combined elements of the practices described above (City of Lacey 1992). Stormwater treatment would help to decelerate lake eutrophication and decrease metals contamination. Increased stormwater maintenance would reduce the load of contaminated sediments delivered to the lakes, and reduce pollutants from flooding caused by stormwater facility failures. Reduced use of chemical fertilizers would also help to decelerate eutrophication. Slower eutrophication would help maintain the stormwater detention function of the lakes and preserve boatable open waters. Reduced levels of toxic metals in sediment would decrease public health risks. Reduced metal levels in sediment could eventually translate to lower metal levels in fish tissue and improved public health and safety. This benefit would probably take years to materialize, however, because metals have already accumulated in the existing sediments.

5.2.11 Hewitt Lake

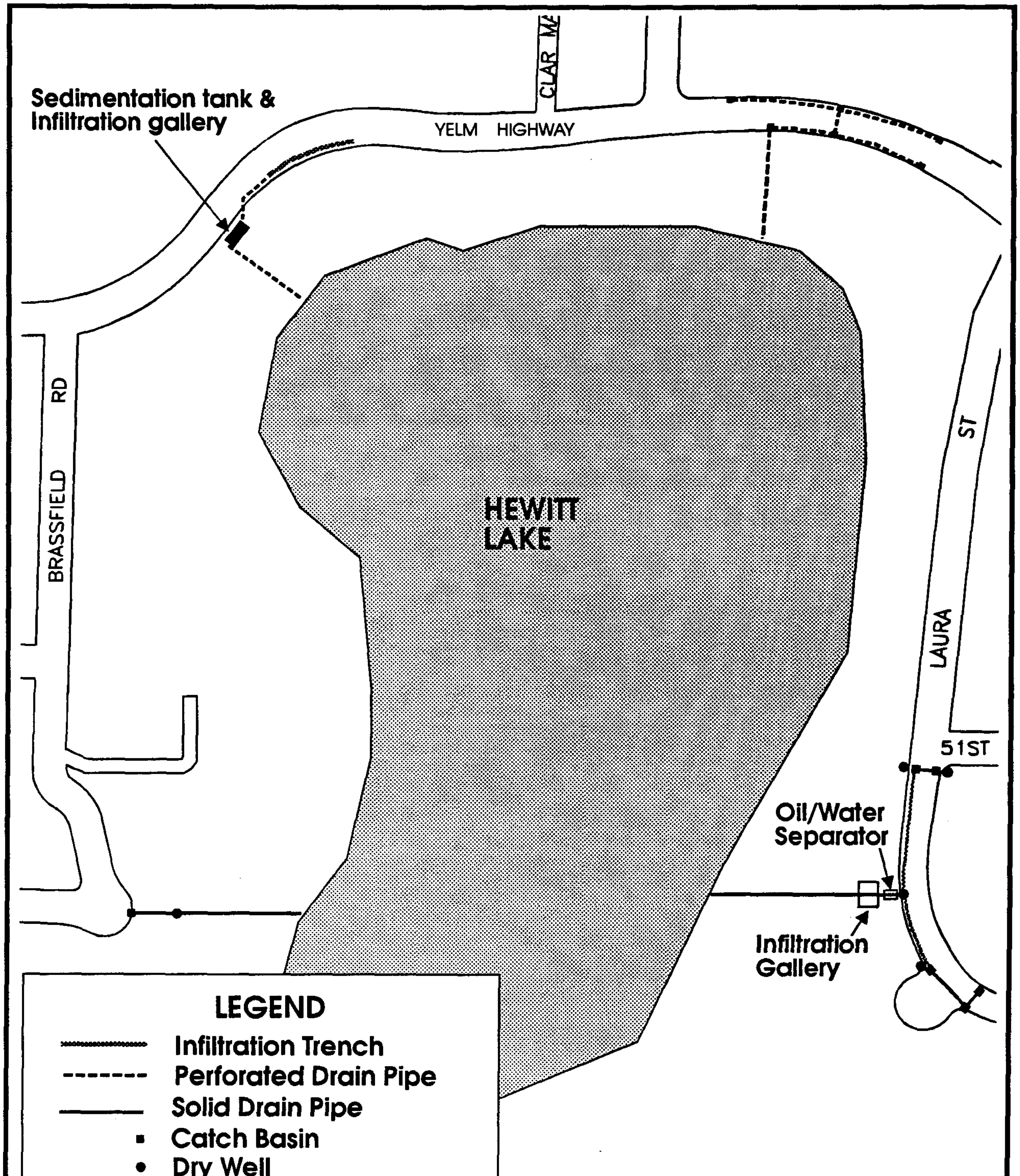
Four stormwater systems discharge to Hewitt Lake: two on Yelm Highway, one on Laura Street, and one on Brassfield Road. The original water quality study design called for sampling the outfall to Hewitt Lake from Laura Street in the Hewitt Lake Park subdivision. However, no stormwater was sampled there because the stormwater outfall remained submerged under the lake surface, so samples could not be collected. Sediment samples were collected, but they did not reveal any significant problems. Hewitt Lake had the best water quality of all the lakes tested in 1992. Nutrient levels were higher than natural levels, but not severe. Fecal coliform contamination was not a problem. Herbicide sprays have been used on the beach on at least one observed occasion. The phytoplankton sampling indicated that the lake is becoming mesotrophic.

Homeowners reported that Hewitt Lake experienced unusually severe blue-green algae blooms in the late summer of 1994, at a time when nearby Ward Lake did not experience algae blooms. Residents reported that the algae blooms persisted into the fall. An algae bloom on Hewitt Lake was also noted in September 1992.

Discussion and Analysis of Alternatives

Algae blooms in lakes are closely related to phosphorous levels and usually occur when mixing or physical disturbance brings phosphorous up toward the surface from the bottom sediments. Disturbances that can cause phosphorous releases from bottom sediments include high winds, rain storms, and dredging.

Low lake levels can also increase the concentration of phosphorous. Hewitt Lake has registered historically low levels in recent years. Phosphorous and nitrogen releases in lakes often increase as temperature increases as dissolved oxygen decreases near the lake bottom. The 1992 data showed corresponding decrease in dissolved oxygen and increases in



Hewitt Lake Stormwater Systems

Thurston County Stormwater
July 1995

temperature, total phosphorous, ortho phosphorous, total nitrogen and inorganic nitrogen at the bottom of the lake in July. The spike in nutrient levels at the bottom dropped off sharply in September. The 1992 algae bloom occurred after phosphorous levels at the surface had dropped rapidly. Available nitrogen levels were fairly high in Hewitt Lake, but nitrogen is usually not the limiting factor in lake algae growth.

The summer of 1994 was very dry, and little rain fell prior to the algae blooms. Some lake residents reported to the county that stormwater discharges caused phosphorous concentrations that led to the algae blooms. However, no stormwater discharges were observed during field visits, and the algae blooms persisted long after brief rains ended. Stormwater discharges can contain phosphorous, but phosphorous is more typically associated with agricultural activities or residential landscape maintenance. Detailed analysis of nutrient loading sources and nutrient cycling processes in the lake would be needed to determine the causes of the algae bloom. Alternatives for reducing lake contamination levels include: increased stormwater maintenance, additional stormwater treatment, and homeowner education.

Increased Stormwater Maintenance. Frequent inspection and maintenance of the stormwater systems that discharge to the lake, including cleaning of catch basins, vaults and oil/water separators, would help prevent stormwater-caused contamination. Stormwater systems tend to accumulate fine sediments, which frequently contain high levels of phosphorous. The sediments in Hewitt Lake were not analyzed for phosphorous.

Stormwater Treatment. The two stormwater systems on Yelm Highway were upgraded fairly recently, but only one of them meets current standards. The other stormwater systems are fairly old and inadequate compared to current standards. Stormwater systems that overflow to the lake could be upgraded to provide additional treatment and infiltration, which would reduce total discharges. The soils around the lake infiltrate readily, so stormwater systems should not need to discharge directly into the lake except during the most extreme rain storms.

Homeowner Education. Homeowner education could help reduce phosphorus loading of the lake. Chemical fertilizers may contribute to nutrient levels in the lake. Studies in Rhode Island and Maryland found that medium-density residential developments have the highest fertilizer loading factors of any land use (U.S. EPA 1993). Studies in Virginia indicated that the average "do-it-yourself lawn caretaker" applies 2-4 times the necessary amount of fertilizer. Programs like Common Sense Gardening and Operation Water Works, described above, would help reduce the use of chemical fertilizers around the lake.

5.2.12 Ward Lake

The sediments in Ward Lake contained the highest concentrations of copper, chromium and nickel of all the lake sediments sampled. The metals could be coming from stormwater systems that discharge to the lake, or they could be remains of historic lake uses such as the old sawmill. Phytoplankton sampling confirmed that the lake is in between oligotrophic and mesotrophic states.

42nd Ave Boat Launch Stormdrain (SW1)

Stormwater and sediment sampling of the storm drain that discharges to Ward Lake in the 42nd Avenue boat ramp area revealed the following problems:

- Stormwater discharged into lake had the highest temperature of all stormwater sampled.
- Samples had very high fecal coliform bacteria on one occasion.
- Stormwater samples had high turbidity, total suspended solids and total phosphorus.
- Sediments contained four metals exceeding comparison criteria, and had the highest copper, lead and zinc levels of all stormwater sediments sampled.
- Sediments contained 10 organic contaminants and had the highest concentrations of all stormwater sediments sampled.

Holiday Hills Stormwater Outfall

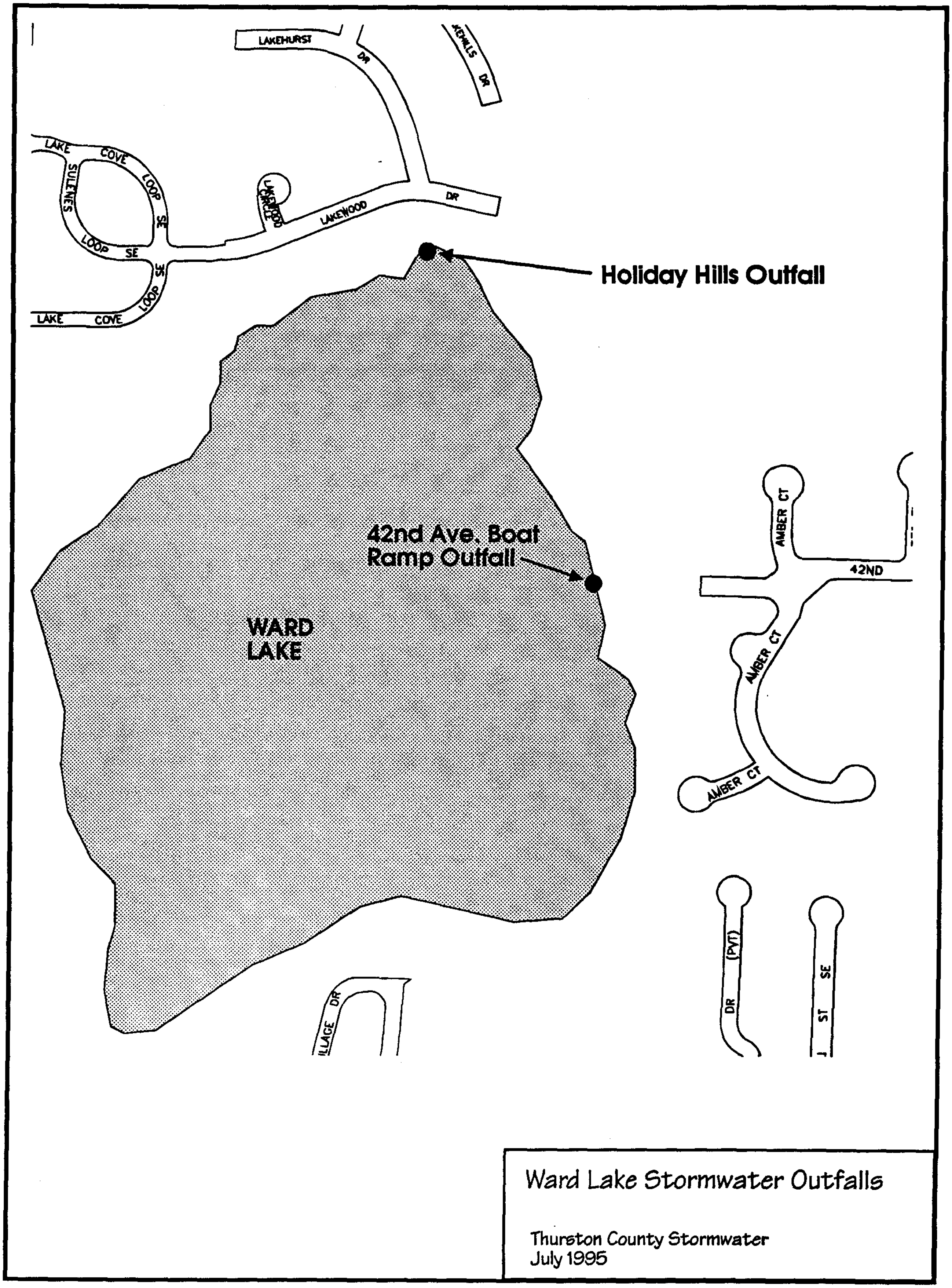
There have been at least two documented instances of spills into Ward Lake from this outfall. A sewage pump station failure resulted in raw sewage spilling into the lake through this outfall. An equipment failure resulted in roof washing chemicals draining into the lake here. The entire storm drain system for the neighborhood drains down through one pipe into the lake, and there is no place on the system where spills can be contained. Residents of Holiday Hills at the north end of the lake have complained occasionally of contaminated discharge from this stormwater outfall, and murky discharges and algae blooms have been photographed at the site. Unfortunately, county staff were not able to sample the stormdrain discharge despite several attempts because the outfall was always submerged under the lake surface during rainfalls.

Discussion and analysis of alternatives

Alternatives for reducing contaminant levels in the lake include: homeowner education, elimination of stormwater discharges, additional stormwater treatment, and septic system monitoring and repair.

Homeowner Education. Some sources of contamination could be reduced through increased homeowner education. Landscaping practices may be contributing to nutrients in the lake, as discussed above. However, education cannot address the toxic metals contamination which probably comes from vehicle traffic.

Elimination of Discharges. The stormwater outfalls could be replaced with infiltration facilities, or treatment could be installed prior to discharge to the lake. The soils are sandy



Ward Lake Stormwater Outfalls

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and reasonably conducive to infiltration. However, the neighborhoods are already developed so construction of infiltration facilities would require excavating streets and lawns, causing major disruptions to the neighborhoods. This could be prohibitively expensive.

Stormwater Treatment. Stormwater treatment facilities could be installed on the outfalls prior to discharge. The 42nd Avenue outfall would require an underground vault system because there is not adequate land to build a pond or wetland system. A vault may provide relatively low sediment removal, and would require frequent maintenance. The Holiday Hills outfall could be fitted with a pond system on the community open space between the road and the lake. Treatment could reduce the contaminated sediments and nutrients draining into the lake.

Septic System Monitoring & Repair. Leaking septic systems are probably the cause of high fecal coliform sampled at the 42nd Avenue outfall, because the stormwater drains exclusively from a residential development that relies on septic systems. A household septic system survey would identify the source of contamination. Owners of failing systems could qualify for low-interest loans to repair their systems.

5.2.13 Untreated Stormwater Discharges

Some stormwater outfalls which have not been monitored discharge directly to surface water in the basin. This basin plan and previous studies targeted outfalls suspected of having the highest probability of contamination. Nothing is known about how much the unmonitored outfalls contribute to water quality degradation.

The unmonitored outfalls could be studied and prioritized for remedial action. Monitoring would require periodic sampling to determine the ambient (background) level of contamination, as well as storm event sampling to identify the specific stormwater contributions. Sampling sediments from stormwater catch basins or outfalls would provide additional clues for prioritizing remedial actions.

Unmonitored outfalls include:
- Chambers Lake Drive & Leisure Way: Little Chambers Lake
- Donnelly Drive: Chambers Ditch
- Hewitt Lake Road: Hewitt Lake
- Yelm Highway: Hewitt Lake
- View Ridge Circle: Smith Lake

5.3 FISH HABITAT PROBLEMS

Declining fish runs result from several factors that are too complex to trace back to individual causes (Reinelt 1992). However, biologists have noted for more than 100 years that habitat loss causes fish runs to decline (Van Cleef 1885), and several biologists agree that habitat loss is the biggest single cause of decreased salmon runs in Puget Sound streams (Bisson 1992; Shuller 1992). This section is limited to the fish habitat problems associated with managing stormwater, not other fish management issues such as fishing quotas or fish stocking rates.

Fish habitat consists of the food, shelter and environmental requirements which fish rely on for their survival. Chapter 3 summarizes the elements of good fish habitat. Every fish species has unique habitat requirements, but this section focuses on the needs of coho. The anadromous fish species found in Chambers Creek include coho, steelhead and cutthroat, but the primary use is by coho and sea-run cutthroat trout (Jim Fraser, personal communication, 1994).

The loss of fish habitat in Chambers basin has resulted from vegetation clearing, erosion, altered hydrology, and water quality degradation.

Vegetation Clearing. Loss of streamside vegetation can result in reduced fish populations (Shlosser 1991; Gregory et al 1991; Sedell and Beschta 1991). Vegetation clearing is most often associated with land development. Vegetation clearing reduces cover and food sources for fish, raises stream and lake temperatures, degrades water quality, increases erosion and sedimentation, and reduces the large woody debris that forms pools (Sedell and Beschta 1991). Clearing forested lands increases the frequency of floods in creeks (Nelson 1992), so the riparian vegetation never gets a chance to recover and grow through natural succession.

Fish Blockages. Artificial blockages to fish migration include undersized and poorly designed culverts which create flow velocities too high for fish to swim against and raised culvert outfalls which create cascades too high for fish to jump. Culverts also tend to block the natural movement of gravel in a stream. Fish blockages reduce a stream's capacity to sustain fish production.

Altered Hydrology. Urbanization alters stream hydrology and causes peak flows up to six times higher greater than natural forested peak flows, and low summer base flows that can limit available fish habitat (Nelson 1992). High peak flows degrade fish habitat directly by reducing the number of available in-stream pools and eddies and washing away streamside vegetation, woody debris, and spawning gravels (Booth 1992). Reduced habitat complexity caused by urbanization decreases the fish population and diversity (Lucchetti 1992).

High peak flows can flood road crossings and block fish passage. Flooding degrades fish habitat indirectly by causing erosion and siltation, and washing contaminants into the stream. Fish and overall stream health often suffer more severe damage from changes to stream hydrology than from water quality degradation (Scott 1982; Steward 1983; Bissonnette 1985).

Water Quality Degradation. Water quality degradation that affects fish habitat includes nutrients that cause algae blooms, low dissolved oxygen levels, soap products, extremely acid or alkaline substances, and sediments. The habitat problems section does not address water quality problems, which are dealt with separately.

5.3.1 Peak Flows on Chambers Creek

The previous section on flooding problems addressed flooding that poses a threat to property, buildings, roads or public safety. This section addresses the impact of predicted future peak stream flows on fish habitat.

Figure 5-1C depicts the predicted increases in peak stream flows under future developed conditions at Rich Road and the mouth of the creek. Field surveys of the creek and ditch, described in chapter 3, indicated that the best fish habitat and the primary fish use occurs below Rich Road but the segment below Yelm Highway is included here because fish have been documented in the Rich Road culvert.

The modeling indicates that stream peak flows will not increase substantially in Chambers Creek in the future, for several reasons. First, much of the basin is covered with outwash soils which infiltrate runoff readily. Recently adopted regulations require new developments on those soils to infiltrate all of their runoff.

Second, soils within the ditch itself infiltrate large quantities of runoff between Wilderness and Rich Road, as described in chapter 4. The ditch absorbs most of the runoff in the fall and early winter, until the groundwater table rises, which helps to mitigate increases in runoff upstream.

Third, the wetland above Rich Road detains a large quantity of runoff, which reduces its impact on downstream flows. Both Chambers Ditch and the South Tributary drain to this wetland.

Flow events with a frequency of two years or less have the greatest impact on fish habitat (Booth 1992). Frequently recurring flows largely determine the vegetation and substrate of the creek. Larger, less frequent events can cause channel damage and affect habitat, but they tend to have a shorter-term impact on fish. Large events may damage the fish runs of a particular year, but the more frequent events determine how the stream recovers and exert more influence on the overall fish population.

The modeling indicates that the one-to-ten year events will not change significantly in the future. Flows near the mouth, where the best habitat occurs, are projected to increase by only about 10-12% for those events.

The Department of Fish and Wildlife provided the following guidance for preventing impacts to fish habitat (letter from Pat Powers and Brian Benson to Thurston County 1991):

1. For the two year storm event, provide sufficient detention to match existing peak flow rates for the ten year natural condition.
2. For the 10 year storm, match the existing peak flow rate for the 100 year natural condition.
3. For the 100 year storm, allow an increase over existing conditions, but consider conveyance of water through the channel and potential bank failure/flooding and erosion problems.

The existing flows at the creek mouth meet these guidelines, and drainage requirements will provide sufficient detention to meet or approach them in the future (see figure 5-1C). The natural 10-year flow at the creek mouth is greater than the existing 2-year flow and equal to the future 2-year flow. The natural 100-year flow is equal to the existing 10-year flow and within 10% of the future 10-year flow. The future 100-year flow will increase by only about 8%, which is not enough to seriously destabilize the stream banks. The projected future peak stream flows do not appear to threaten fish habitat in Chambers Creek.

5.3.2 Degraded Riparian Habitat on Chambers Creek

The riparian tree canopy gives way to open fields south of Chambers Creek below Rich Road, although some trees still line the creek. The north side has healthy forest cover on the hill below the railroad grade. This stretch of the creek flows year-round and offers rearing habitat for coho salmon.

The forest on the north side of the creek provides a source of large woody debris for the creek, but the south side offers minimal shading. Replanting riparian tree species along the south side would improve shading of the creek.

5.3.3 Sedimentation at Rich Road

The gravel immediately downstream of the culvert under Rich Road is small (< 1") and highly laden with sediment. The sources of sediments have not been documented. One possible source is animal use of the creek upstream, though farm animals were recently removed from the land next to the creek. Ditch maintenance activities upstream from Rich Road, and road runoff are other possible sources.

The sediment affects fish habitat by degrading the gravel for salmon spawning. Coho use the creek primarily for rearing, not spawning, but salmon spawning sites have been observed in this segment of the creek (Grant Fiscus, public meeting, 1995). The high velocity of water discharging from the Rich Road culvert also makes the site less than ideal for spawning.

The sediment-laden gravel could be removed and replaced with clean spawning gravel or the existing gravel could be washed out with a "riffle washer", a hydraulic pump that forces fines up and out of the stream bed. New gravel would improve the spawning habitat value of the streambed. Unfortunately, the clean gravel would become embedded with new sediments unless the source of the sediment is controlled. Also, cleaning the gravel destroys the aquatic insects in the stream bed, which are the main food supply for rearing fish. Additional monitoring could help to identify the sediment sources.

5.3.4 RICH ROAD CULVERT

The Rich Road culvert may block fish passage during high flows due to high water velocity. Limited numbers of coho have been reported to pass through the culvert. Further investigation by the county and the Department of Fish and Wildlife is needed to determine if this is a problem. This segment of the stream contains very little large woody debris, rocks, or other features that could reduce the impact high-velocity flows through the culvert.

Habitat features such as boulders and logs could be placed in the channel to provide refuge from the high velocities, and baffles could be placed in the culvert to improve it's accessibility for migrating fish. These measures would increase access to rearing habitat upstream.

5.3.5 WARD AND HEWITT LAKE HABITAT

The primary concerns of the Department of Fish and Wildlife regarding fish habitat in Ward and Hewitt Lakes include preservation of lakeside vegetation (Debbie Carnevali, personal communication, 1994) and maintaining adequate lake levels (Jay Hunter, personal communication, 1994).

Preservation of Lakeside Vegetation. The Shoreline Master Program (Title 19 of the Thurston County Code) requires developments to preserve a 50′ wide buffer along the edge of any lake. Sometimes a buffer requires additional planting or enhancement to function properly. The buffer is intended to consist of undisturbed, natural vegetation, which can help remove pollutants from runoff such as excess lawn fertilizers. Fertilizer runoff is important to keep out of the lakes because the nutrients cause algae blooms. Some citizen task force members and other basin residents who attended task force meetings remarked that enforcement of the existing regulations is not adequate.

Maintaining Adequate Lake Levels. The level of Ward and Hewitt Lakes drops significantly during dry years. The levels of most Thurston County lakes have declined for several years and reached historic lows in 1994. Declining lake levels change the composition of the lake shore vegetation and reduce the total length of shoreline, which is critical habitat for the resident fish. As the lake level drops, shallow areas warm up and become more choked with aquatic weeds.

Increased aquatic vegetation also affects water quality by accelerating the rate of nutrient cycling. Increased aquatic vegetation results in more plant matter growing and decaying in the water. As the plants grow, they absorb nutrients from the water. As they decay, they recycle nutrients back into the water and deplete the water of dissolved oxygen. The low water level also impedes use of boat launches.

Ward and Hewitt Lakes depend primarily on precipitation in the surrounding basin, which recharges the groundwater that feeds them. When precipitation declines during periods of drought, ground water and lake levels decline. Recent lake levels declines throughout the county mirror drops in well levels. Increased impervious area from development decreases lake levels by reducing rainfall infiltration and increasing evaporative water loss.

Discussion and Analysis of Alternatives

Alternatives for preserving and improving lake habitat include education and improved enforcement. Maximizing stormwater infiltration can help maintain lake levels.

Education. Education programs could help protect lakeshore vegetation and remind residents of the value of keeping a vegetated buffer along the waterfront. Volunteer lake-watch programs, interpretive signs at recreation areas, and information packets for lakeside residents could help achieve water quality and habitat goals.

Improve Enforcement. Local governments' primary regulations for protecting lake shore habitat are the shoreline master programs, which prohibit clearing of lake shore vegetation for development. Development proposals are checked for compliance with shoreline requirements during the local environmental review (SEPA) process. Conditions such as shoreline setbacks may be placed on a development proposal. Each jurisdiction handles inspection and enforcement of permit conditions differently. Olympia employs environmental code enforcement personnel, but Lacey and Thurston County rely on building field inspectors for enforcement of environmental requirements. Most clearing occurs during the initial stages of construction, when inspectors check for grading compliance. Additional training for inspectors on environmental requirements and improved coordination between permitting and enforcement activities could improve enforcement of existing regulations.

Increase Infiltration. Existing regulations require new developments to infiltrate their stormwater on-site to the maximum extent possible, which helps insure that the groundwater which feeds the lakes continues to be recharged in the future. Infiltration is limited mainly be soil characteristics, and the soils around Ward and Hewitt Lakes are conducive to infiltration. Infiltration could be increased by limiting the impervious coverage of developments through techniques such as narrower streets and shared parking.

5.3.6 CHAMBERS/LITTLE CHAMBERS LAKE LEVEL FLUCTUATIONS

Chambers and Little Chambers Lakes are highly sensitive to water level changes because the lakes are so shallow and the surrounding land is flat. Water level declines of as little as one foot cause large areas of the lakes to dry up completely, and encourage even more aquatic weed growth. As the lake levels drops, the water temperature rises to the point where it could harm cold-water fish species.

Discussion and Analysis of Alternatives

The ground water table and stormwater runoff largely determine the lake levels. An outlet structure regulates the lake levels in the winter when the ground water table is high. During the dry season, once the lake levels fall to below the elevation of the outlet weir, groundwater table fluctuations control the lake levels. Winter precipitation in the nearby area regulates the groundwater table. Most of the rainfall in the basin would infiltrate into the ground in a natural condition, and the slow movement of groundwater in and out of the lake would reduce rapid fluctuations.

Development in the basin has reduced the area available for infiltration and routed significant quantities of rainfall into stormwater systems that drain directly to the lake, causing more rapid lake level fluctuations and lowering the groundwater table.

Increasing infiltration of stormwater runoff and decreasing the direct discharges would help reduce lake level fluctuations and the resulting impacts to fish habitat. Alternatives for increasing infiltration include retrofitting individual lots, installing infiltration on stormwater outfalls, and limiting impervious coverage in new developments.

Retrofit Individual Lots. Infiltration could be increased at the source, by redirecting runoff from individual homes and streets to infiltration facilities. Roof downspouts could be directed to french drains. Infiltration trenches could be installed along streets. This alternative would probably be prohibitively expensive due to the cost of designing and constructing multiple systems in developed areas. A recent drainage engineering study concluded that upgrading all the individual infiltration facilities in a Woodland basin development would cost $67.4 million (Entranco 1994).

Retrofit Stormwater Outfalls. Infiltration could be increased by intercepting the stormwater discharge pipes and routing the runoff to infiltration facilities. Saturated soils around the lake would probably limit the amount of stormwater that could be infiltrated in some locations.

Infiltration of stormwater would reduce lake level fluctuations, reduce the water quality impacts of stormwater runoff, and could help to reduce peak stream flows in Chambers Ditch in the winter.

Limit Impervious Coverage. Measures to limit new impervious coverage in developments, described in the previous section, could prevent future development from exacerbating lake level fluctuations.