Final Draft

Salem Wastewater Management Master Plan

CH2M HILL

June 1996

August 1996

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Acknowledgments

The plan resulted from the contributions of many people over many months. The Water and Wastewater Task Force, consisting of city councilors and community representatives, provided oversight for the preparation of this document.

In order to obtain fresh, objective outlooks from other professionals, the City and its consultant, CH2M HILL, conducted a peer review workshop. The Peer Review Committee consisted of respected members of public works departments and consulting engineering firms.

The following individuals are acknowledged for their important role in the preparation or adoption of the Salem Wastewater Management Master Plan.

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Glossary

Admin.	Administration
BOD (BOD_5)	Biochemical oxygen demand
CBOD ($CBOD_5$)	Carbonaceous biochemical oxygen demand
CDA	The City of Salem's currently developed area
CIP	Capital Improvement Program
DEQ	State of Oregon, Department of Environmental Quality
EC or *E. Coli*	*Escherichia coli* can be a disease causing organism
ENR	Engineering News Record
EPA	United States, Environmental Protection Agency
EQC	United States, Environmental Quality Commission
FC	Fecal coliform
FPW	Food processing water
GIS	A geographical information system combines the benefit of computer database management with graphics capability to enable visualization of selected data elements.
HPOAS	High purity oxygen activated sludge
I/I	Infiltration/inflow. Infiltration is the flow entering the sanitary sewer resulting from high groundwater or precipitation that occurred days or weeks prior to the observed flow in the sanitary sewer. Inflow is the rainfall that enters the sanitary collection system from sources such as catch basins, roof drains, foundation drains, open manhole covers, and other direct connections.
MAO	Mutual Agreement and Order
mg	Milligrams
mg/L	Milligrams per liter
mgd	Million gallons per day
MW	Mitigation wetland
NPDES	National Pollutant Discharge Elimination System
NTS	The Natural Treatment System treats wastewater by using naturally occurring processes of plants and microbes in a planned and controlled system. It is composed of the Overland Flow System and the Wetlands Treatment System.

O&M	Operations and maintenance
OFS	The Overland Flow System will provide treatment of wastewater flows before they enter the wetland treatment system. It is a series of strips of land planted with a mix of grass and poplar trees. Constituents removed or transformed by the system include biochemical oxygen demand, total suspended solids, phosphorus, and ammonia.
pH	Intensity of the acid or alkaline condition of a solution
Plan	The Salem Wastewater Management Master Plan is to provide a long-range wastewater service plan for existing and future customers within the Salem Urban Area Growth Boundary.
RDI/I	Rainfall dependent infiltration and inflow is the total flow entering the sewer system as a direct result of a rain event.
SCADA	Supervisory control and data acquisition
SSES	Sewer system evaluation study
SSOs	Sewer system overflows
TSS	Total suspended solids
TW	Treatment wetlands
UGB	Urban area growth boundary
UV	Ultraviolet radiation disinfection
WTS	A Wetland Treatment System provides water quality treatment. The microbial flora that attach to the plants have the natural assimilatory capacity to remove biodegradable organics and nitrogen efficiently and reliably.
WWTP	Wastewater treatment plant
XL	U.S. EPAs Environmental Excellence and Leadership Program
XP-SWMM	A software package based on EPA's Storm Water Management Model (SWMM) that has enhanced interfaces to create model input and view model results. This tool is used to model the flows and system capacities in the sanitary sewer system.

SECTION 1

Summary

Guiding Principles

The overall goal of the *Salem Wastewater Management Master Plan* is to provide a long-range wastewater services plan for existing and future customers within the Salem Area Urban Growth Boundary. To meet this overall goal, the City, with the involvement of its citizens and engineering consultants, has developed the following guiding principles for the Master Plan:

Environmental Stewardship

- Continue sound environmental stewardship
- Continue as stewards of the wastewater infrastructure
- Anchor planning in sound principles of environmental science, economics, and engineering
- Provide a long-term vision for system improvements and expansion consistent with land use plans
- Identify cost-effective solutions for:
  - Reducing and eliminating public exposure to sewer system overflows and basement flooding
  - Controlling sewer system overflows to the Willamette River and its tributaries consistent with permit requirements
  - Providing cost-effective sewer services to City customers (residents, businesses, industry)
- Provide a feasible implementation strategy for timely construction of improvements
- Plan for cost-effective compliance with future regulatory requirements

All wastewater system components have been planned to be in compliance with the Comprehensive Plan.

Summary of the Plan

The Salem Wastewater Management Master Plan deals with two main issues: the collection and conveyance of wastewater and the effective treatment, disposal and reuse of that wastewater. The heart of the plan is a decision process that allows wastewater master planners to evaluate alternatives and arrange them in order of preference based on the guiding principles listed above. If a preferred alternative proves not to be acceptable as we move from planning to action,

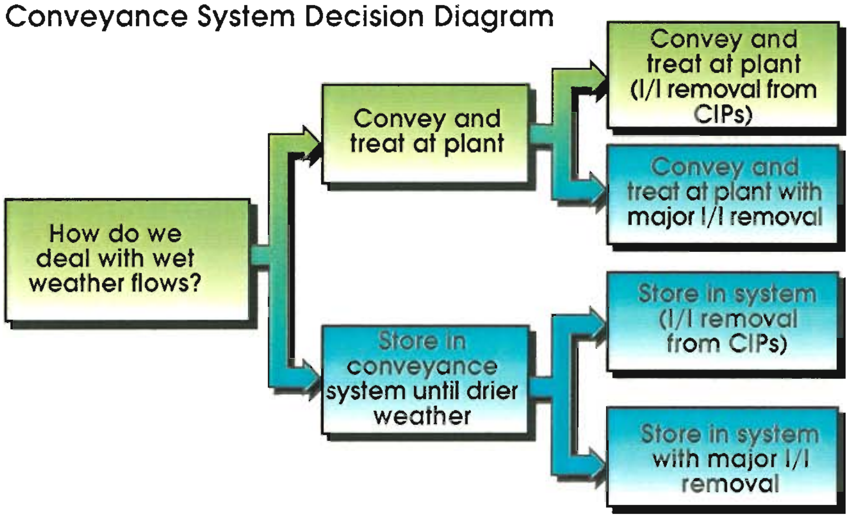
Infrastructure Stewardship

planners can step back in the decision process and go forward with the next best alternative.

For the conveyance system, the preferred alternative is to convey and treat all wastewater at/to the Willow Lake Wastewater Treatment Plant. Infiltration and inflow (I/I) removal from the sewer system will occur through the Capital Improvement Program (CIP). The decision diagram for conveyance is shown as Figure 1-1.

Figure 1-1

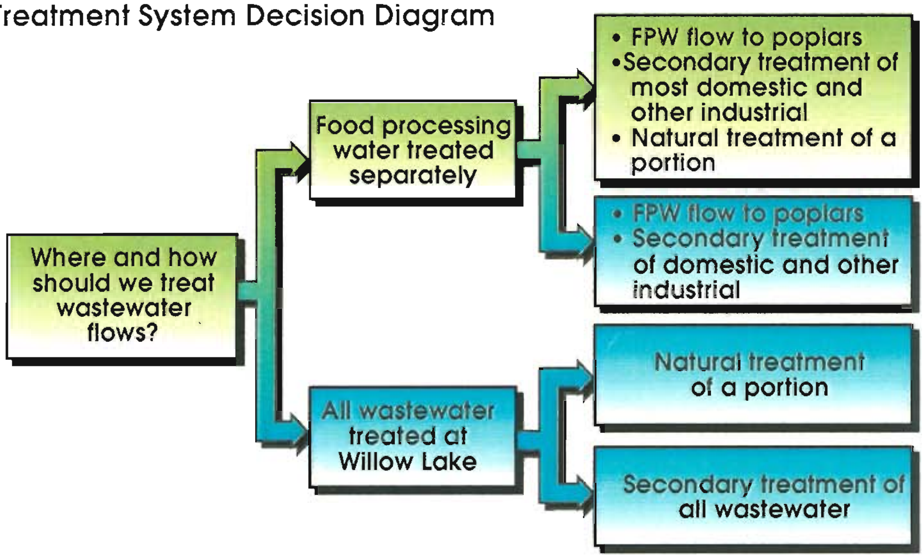
Conveyance System Decision Diagram



Once the preferred conveyance alternative was chosen, the treatment alternatives were assembled and evaluated, resulting in the decision diagram below (Figure 1-2). The preferred alternative is to treat a portion of the food processing water (FPW) at a separate poplar plantation and to provide secondary treatment and a natural treatment system for the remainder at Willow Lake.

Figure 1-2

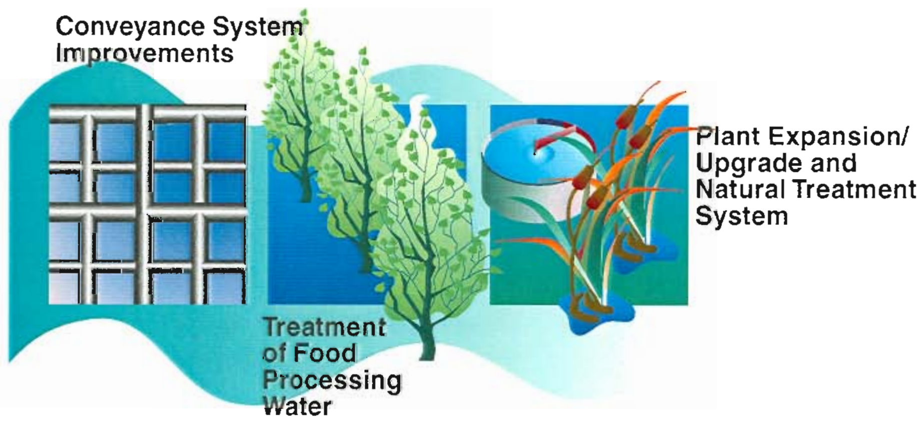
Treatment System Decision Diagram



Overview of the Preferred Alternative

To implement the preferred conveyance alternative, a series of capital improvement projects is recommended in the plan and its supporting documents. These projects will alleviate the conveyance system's overload and control the overflows that now discharge into the Willamette River during particularly heavy rainfall events to a level authorized by the regulatory agency.

The wastewater collected and conveyed by the sewer system requires effective treatment for the City to meet its environmental stewardship goals. The treatment facilities in this plan rely upon a combination of conventional treatment processes and innovative natural treatment systems to meet water quality standards and to minimize cost. If all the wastewater generated in the City were to go to the Willow Lake Wastewater Treatment Plant (WWTP), the required expansion would be significantly more costly. In the selected plan, the process water from some of the large food processors in the area will be conveyed to a separate location and treated naturally by a plantation of poplar trees. Additionally, a natural treatment system at the Willow Lake WWTP site will complement conventional treatment of wastewater.



Conclusions and Recommendations

The master planners gathered and analyzed information to reach specific conclusions about the City's system. The conclusions led to recommendations that are embodied in the preferred alternative. The most important conclusions and recommendations are summarized below.

Conclusions

- The volume of wastewater flow is projected to increase by about 50 percent over the next 20 years.

- Conveyance of domestic and commercial wastewater to the treatment plant is more cost-effective than other alternatives that involve significant work on the conveyance system.
- The City's current wastewater conveyance system is well designed and maintained, but aging. Some rehabilitation is required, and the system must be expanded in increments as required to provide service to the limits of the Urban Growth Boundary.
- Wastewater collection system improvements are needed to meet the 5-year 24-hour overflow criteria of Oregon Department of Environmental Quality.
- Treatment of food processing water at a poplar plantation separate from the Willow Lake WWTP provides an effective, least-cost solution to heavy loadings to the plant.
- The Willow Lake WWTP will continue to be the City's treatment plant and will be expanded and upgraded.
- A natural treatment system at the Willow Lake site provides wastewater treatment, operations flexibility, and a "green alternative" at a lower cost than other alternatives.

Recommendations

- Complete the public review and formal adoption process for this plan.
- Complete negotiation of the Mutual Agreement and Order (MAO) with the Oregon Department of Environmental Quality (DEQ) and implement its provisions.
- Submit the plan to the U.S. Environmental Protection Agency (EPA) for consideration under their Environmental Excellence and Leadership (XL) Program.
- Eliminate the tributary sanitary sewer overflows resulting from a 5-year storm event and provide even greater protection from basement flooding by the year 2000.
- Implement the conveyance system Capital Improvement Program as outlined in this plan.
- Replace or rehabilitate sewer service laterals in conjunction with adjacent mainline sewer replacement or rehabilitation.
- Adopt a perpetual life program for the conveyance system to improve and then maintain the physical integrity of the conveyance system.
- Relieve the Willow Lake WWTP of high organic loadings as soon as practical through implementation of separate treatment of a major portion of food processing water.
- Develop a natural treatment system to complement the conventional treatment system at the Willow Lake WWTP.

- Implement the first phases of the food processing water and natural treatment systems to address current organic capacity problems and to optimize the overall Willow Lake conventional and natural treatment systems.
- Acquire, as soon as possible, the additional lands necessary to site the natural treatment systems (NTS) adjacent to the Willow Lake WWTP.
- Identify and acquire the lands and rights of way necessary to site the food processing water treatment system as soon as possible.
- Expand the Willow Lake WWTP conventional treatment facilities after the performance of the NTS is assessed and plant design criteria are modified to reflect NTS performance.
- Coordinate plant expansion with new interceptor capacity from Union Street to Willow Lake WWTP.
- Complete early predesign of supplementary wastewater conveyance from Union Street to the Willow Lake WWTP and acquire necessary rights of way in the near future.
- Undertake interim Willow Lake WWTP improvements necessary to meet water quality requirements and biosolids management needs.

Policies

The following policy statements are based on the results, conclusions, and recommendations of the *Salem Wastewater Management Master Plan* to help promote the efficient and effective implementation of the plan by the City.

Engineering Criteria

It shall be the policy of the City to follow the engineering planning criteria developed in the *Salem Wastewater Management Master Plan* and supporting documents to evaluate, design, and construct future improvements to Salem's wastewater system.

Salem Area Comprehensive Plan

It shall be the policy of the City to plan facilities for the population growth projected in the Salem Area Comprehensive Plan.

Industrial Wastewater Pretreatment

It shall be the policy of the City to further develop and implement the Industrial Pretreatment Industrial Grant Program.

Reserve Capacity

It shall be the policy of the City to maintain a 5-million-gallon-per-day (mgd) wastewater treatment capacity reserve at all times. The 5-mgd reserve will provide for unanticipated wastewater needs.

Wastewater Service Outside Salem's City Limits

It shall be the policy of the City to not provide wastewater service to areas outside Salem's city limits, except as provided in specific contracts with City of Keizer, East Salem Sewer District, and Labish Sewer District or as authorized by the Salem City Council.

Future Improvements to Serve Outside the CDA

It shall be the policy of the City to require that future improvements to the City's wastewater system to serve property outside the Currently Developed Area (CDA) by development be paid as defined in the urban growth management policies adopted by the City Council. These improvements include sewerlines, sewer appurtenances, new sewage pump stations, and expansion to the capacity of existing sewage pump stations.

Future Sewerline Alignments and Sizing

It shall be the policy of the City that future sewerline alignments shown in the Master Plan are approximate because of the limited level of detail contained in a planning document. The final alignment will be determined by the Public Works Department at the time the improvements are required. The future sizes shown in the Master Plan are the sizes necessary to adequately convey projected wastewater flow rates. The final sizes will be determined by the Public Works Director or staff at the time the improvements are required.

At the time of decision, improvements will be reviewed based on, but not limited to, availability of downstream sewer capacity, existing and future flow rates, and pump station capacity availability. Any variation approved must meet the defined flow rates determined in the Plan.

Redundancy for Wastewater Pump Stations

It shall be the policy of the City that wastewater pump stations be designed and constructed to function during a power outage. Small stations shall have the capability to connect a portable electrical generator to provide power to the station. Large stations may be required to have the capability for onsite emergency power generation or secondary power feeds.

Basic Design Criteria

It shall be the policy of the City that the basic concept of the wastewater system envisioned in the Plan is a gravity system. Pump stations and force mains will be minimized and will not be allowed unless approved by the Public Works Director.

Developer-Supplied Engineering Calculations

It shall be the policy of the City that it is the responsibility of developers to demonstrate compliance with the requirements set forth in this Plan to the satisfaction of the Public Works Director. Such compliance may require the developer to supply independent engineering calculations to prove available capacity and consistency with the adopted wastewater system hydraulics model.

Reference Documents

Detailed background to the material in this document is contained in two volumes of supporting documents, *Salem Wastewater Management Master Plan Supporting Documents* (Appendices 1-13), a copy of which can be reviewed at the Public Works Department or the City Library at the Civic Center.

SECTION 2

Existing Conveyance and Treatment Facilities

Conveyance System

Current System Operation

The City of Salem sewer system collects wastewater from an area of approximately 25,000 acres and conveys it to the Willow Lake WWTP. The entire sewer system includes 630 miles of sewer ranging in diameter from 6 to 75 inches. The system includes a supervisory control and data acquisition (SCADA) system for continuous monitoring of its 30 lift stations. The service area includes the following:

- City of Salem
- City of Keizer
- East Salem Sewer and Drainage District
- Labish Sewer District

In 1995, the average wastewater flow, measured as it entered the treatment plant, was 40.7 million gallons per day (mgd). The flow can range up to a much higher amount, however, straining the capacity of the conveyance system. During very wet weather when soils are saturated with rain, the flows into the conveyance system can reach a rate greater than 155 mgd. The current capacity to convey wastewater flows and process them at Willow Lake , however, is restricted to a rate of 105 mgd.

Because the system cannot carry all the flow during peak storm-related flow conditions, three permitted outfalls discharge a mixture of storm water and untreated sewage directly into the Willamette River. However, the sewers may also back up and overflow at manholes. Also, basements in low-lying areas occasionally flood under storm conditions.

An example of system operation under extremely wet conditions occurred as a result of a storm on February 17, 1995, during which 2.6 inches of rain fell in 24 hours. On the average, a storm event of this or greater size is expected to happen once in every 5 years (thus it is known as a 5-year 24-hour storm event). During this event, the Union Street and North River Road outfalls discharged an estimated 61 million gallons, another estimated 1.5 million gallons was discharged at the Musgrave Pump Station overflow, and another half a million gallons was estimated to have overflowed from 31 manholes, for a total of 63 million gallons. At this time the Willow Lake treatment plant was operating at its highest capacity, 105 million gallons per day.

Specific objectives of the master plan seek to alleviate these conditions:

- Prevention of sewer system overflows (SSOs) as a result of a 5-year 24-hour storm event or less severe storm in both the near term and the long term.
- Prevention of basement flooding as a result of storms up to 25 percent greater than the 5-year storm.

The Challenge of the Future

As the population of the Salem area grows, the conveyance system, including sewer lines and lift stations, will have to be expanded. At the same time, much of the existing collection system is aging (nearly 100 years old) and will need replacement. Funding for these replacement projects must compete for limited resources with new conveyance facilities needed to meet regulatory requirements and population growth.

Meanwhile, operations and maintenance of the existing conveyance system must continue to protect the public's investment in the existing facilities. The City must also maintain an active program to find and eliminate sources of rainwater and groundwater that enters the system and greatly increases the total flows. Using new and emerging technology can reduce the cost of rehabilitation of the existing conveyance system.

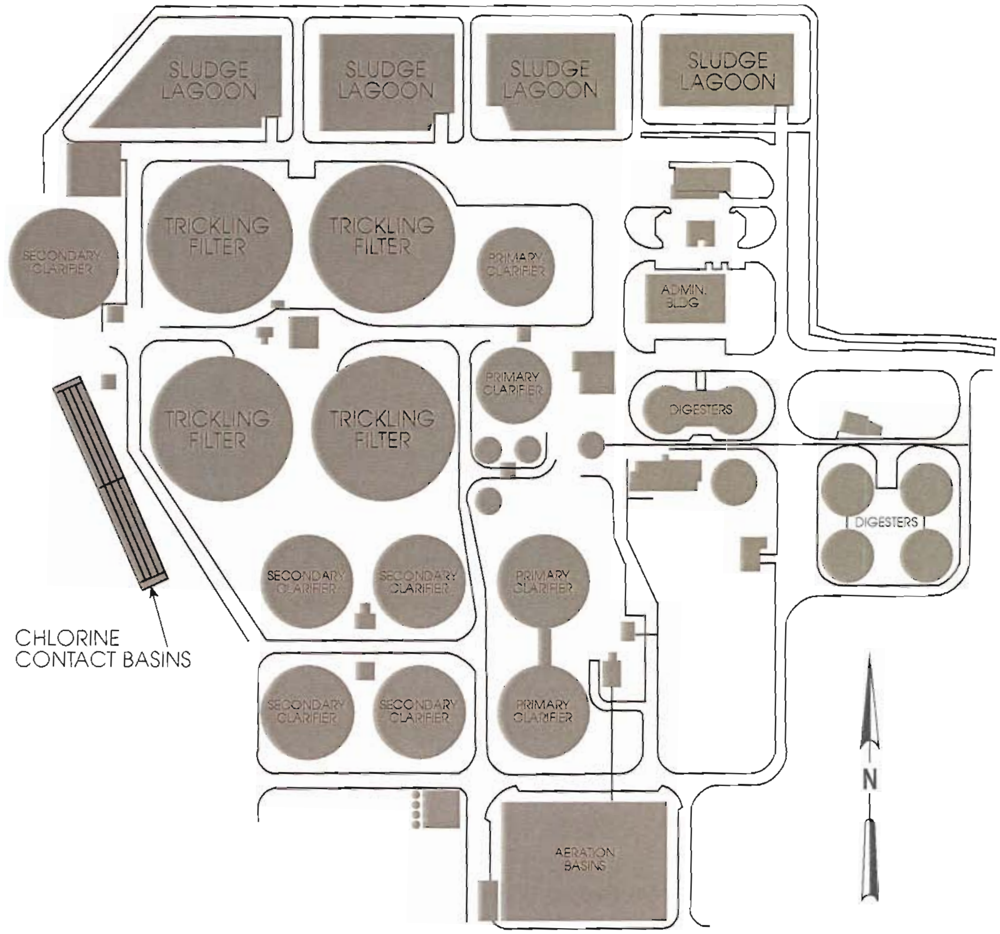
Willow Lake Wastewater Treatment Plant

Current Plant Operation

The Willow Lake WWTP has been effectively treating the area's wastewater for more than 30 years.

The Willow Lake WWTP was originally constructed in 1963. The plant's secondary treatment facilities consisted of four trickling filters and one secondary clarifier, an area now referred to as the North Plant. In 1975, the plant was expanded to provide additional treatment for a growing population and to meet the increasing demands of the local food processing industry. The 1975 addition, known as the South Plant, was originally designed as a high-purity oxygen activated sludge system (HPOAS) and was modified in 1986 to operate as either a HPOAS or, when coupled with the trickling filters in the North Plant, as a trickling filter/activated sludge system.

Figure 2-2
Willow Lake WWTP Site Plan (Existing)



Treatment of sludges is accomplished by anaerobic digestion before application on private agricultural lands. Land application of biosolids has been continuous since 1963, and Salem's BIOGRO program is nationally recognized as a successful biosolids reuse program.

Willow Lake is designed to process 35 million gallons of wastewater a day (mgd) in the dry season and is capable of handling a peak of 105 mgd during the wet weather season. The organic constituents of the wastewater are measured in pounds of biochemical oxygen demand and total suspended solids (BOD and TSS). The amount of these constituents is referred to as the "loading;" Willow Lake is rated for a maximum week loading of 168,200 lb/day of BOD.

The 1995 average annual influent wastewater flow and loadings to the Willow Lake WWTP were:

	1995
Flow (mgd)	40.7
BOD (lb)	69,700
Maximum week BOD (lb/day)	148,000
TSS (lb)	47,000

The maximum week BOD loading fluctuates depending on industrial operations. For example, in 1994, the maximum week BOD was 169,000 lb/day, slightly exceeding the plant's design capacity.

The Challenge of the Future

The Willow Lake WWTP has been effectively treating the area's wastewater for more than 30 years, but aging facilities, increased dry season loading bordering on plant capacity, stricter environmental regulations, and increasing flows require rehabilitation and expansion. During the peak of the food processing season in the late summer and fall, the plant has been loaded at or near its rated capacity. This has made plant operation to comply with discharge permit conditions extremely difficult and has contributed to the release of objectionable odors beyond the plant boundaries resulting in odor complaints. The wastewater loadings will continue to increase as the current service area population of 170,000 increases to a projected 254,000 by the year 2027. If all industrial loads continue to go to the Willow Lake treatment plant, there will be no available capacity during the food processing season to accommodate this projected increase in service population.

The North Plant facilities, in operation since 1963, are experiencing reduced performance and require additional maintenance. As an indicator of age, some buried piping has failed, resulting in emergency repairs. Trickling filters cannot be loaded to current design levels without significant odor emissions.

The existing chlorine-disinfected effluent is discharged into the Willamette River; dechlorination will be required by DEQ to meet water quality standards. In addition, the amount of ammonia in the effluent may become an issue, especially during low river flow periods in the dry season. Currently, the plant cannot sufficiently reduce the amount of ammonia in its effluent. During the period of the initial design of the plant in 1963 and later modifications and expansions, these water quality standards had been neither programmed by DEQ nor anticipated by the City.

SECTION 3

Wastewater Quantities and Characteristics

The quantities and characteristics of wastewater determine the size of wastewater treatment works and the types of systems and processes used there. In turn, the quantities and characteristics depend on the population served by the facilities and on the kinds of contributors to the wastewater flow. The types of flow are divided into domestic flow, which comes from households and from commercial establishments, and industrial flow, a large portion of which, in Salem, comes from food processing facilities. Characteristics of the wastewater are described as "loadings" to the treatment facilities and are measured in pounds of biochemical oxygen demand and total suspended solids (BOD and TSS).

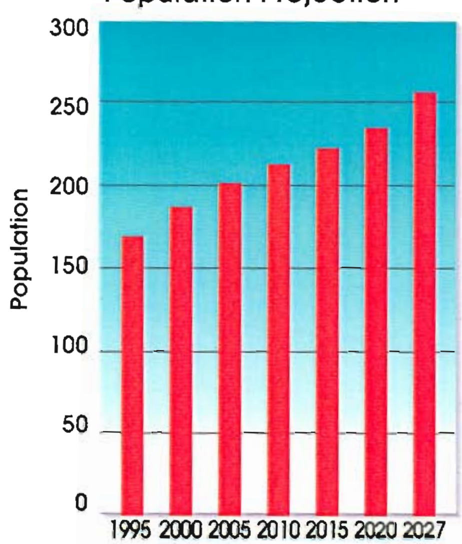
Western Oregon's climate affects treatment plant design also because quantities and characteristics change with the weather and so do permit requirements for river discharge. In general, the requirements are stricter during the dry season—May through October—and more lenient in the wet season—November through April—as a result of increased river flows. Therefore, wastewater projections are grouped into dry and wet seasons.

The typical time period for wastewater facilities planning is 20 years. For this master plan, the period extends to the year 2027, at which time the area inside the current urban growth boundary is projected to be fully developed.

Population Projection

The population projections for the design period are shown in Figure 3-1 (data obtained from the *Salem-Keizer Area Transportation Study*, 1994). By analyzing the quantities and characteristics of wastewater produced by the population in the past, we can project future wastewater treatment needs.

Figure 3-1
Population Projection



Domestic Wastewater Projection

To determine the future quantities and characteristics of domestic wastewater, planners used flow and loading data for 1991 through 1994 from the Willow Lake WWTP and divided by the population to find the per capita flows and loadings. The per capita numbers multiplied by the population projections produced the projected flows and loadings that the plant must treat during the design period.

Designers need to know what flows and loadings might be expected on the average in the dry and wet seasons, and they need to know the highest flows and loadings that could reasonably occur. To determine the high numbers, planners compared the average amounts to the highest amounts and computed a ratio known as the "peaking factor." Salem's peak rates for flow, BOD, and TSS ranged from 2 to 3 times the average flow rates. These peaking factors are comparable to those for many western Oregon cities.

Figure 3-2
Projected Dry Season Domestic Flows

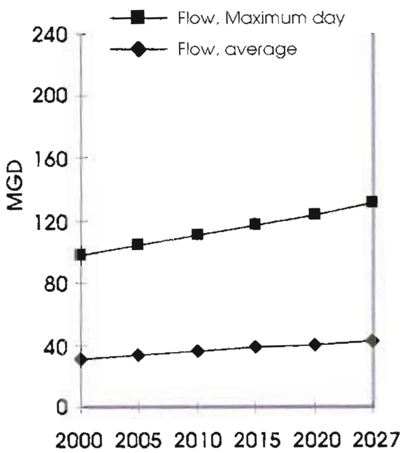


Figure 3-3
Projected Wet Season Domestic Flows

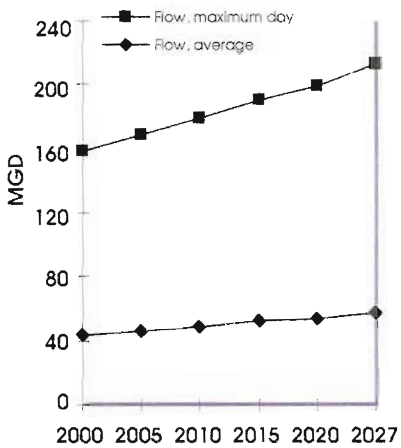


Figure 3-2 shows how many million gallons of wastewater from domestic sources are expected to flow to the treatment plant each day in an average dry season month in the years 2000 through 2027. The graph also shows the maximum amount projected to flow to the plant on the day with the highest flow of the dry season. The same measurements are shown for the wet season in Figure 3-3.

Similarly, BOD and TSS loadings were projected for the design period. Figures 3-4 and 3-5 show the same information as shown for flow: the average day loadings and the maximum day loadings. In Appendix 3, *Design Flows and Loadings,* the data are presented for average, maximum month, maximum week, and maximum day for all measurements of flows and loadings.

Figure 3-4
Projected Dry Season Domestic Loads

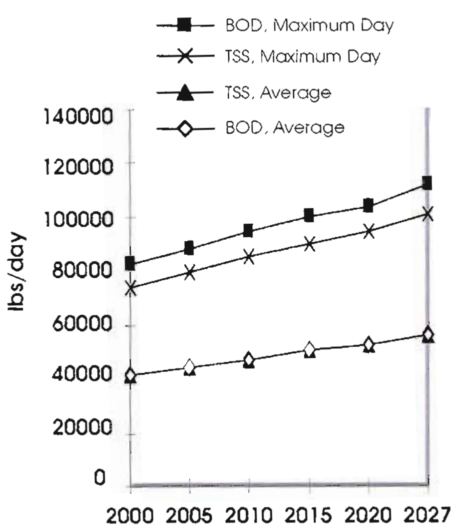
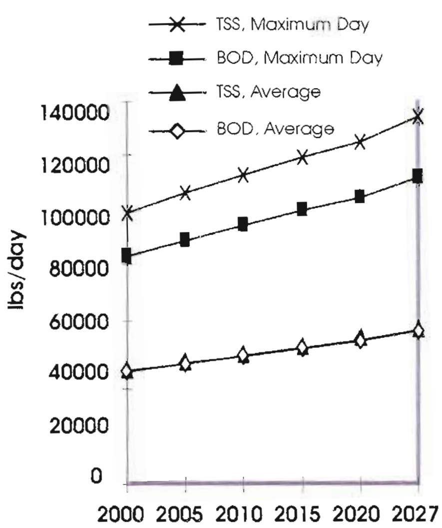


Figure 3-5
Projected Wet Season Domestic Loads



Industrial Wastewater Projection

The same measurements of quantities and characteristics that were projected for domestic wastewater were projected for industrial wastewater; however, the method for projection was different. A confidential survey was sent in 1994 to all 16 industries that are monitored by the City to collect their flow and loading projections. Nine of the 16 industries responded. To calculate the wasteload projections for nonrespondents, historical loadings were projected for the future years.

After evaluation of the survey results, the difference between high and low projections was less than 10 percent; therefore, planners and the industries agreed to use only the high projections. In addition, an allowance of 5 mgd of flow and 15,000 lb/day of BOD and of TSS was added for industries that might locate in the Salem area during the planning period.

Figure 3-6
Projected Dry Season Industrial Flows

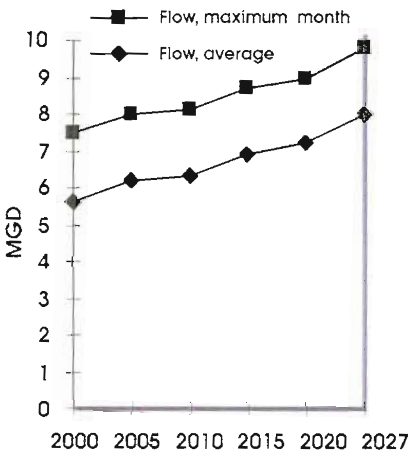
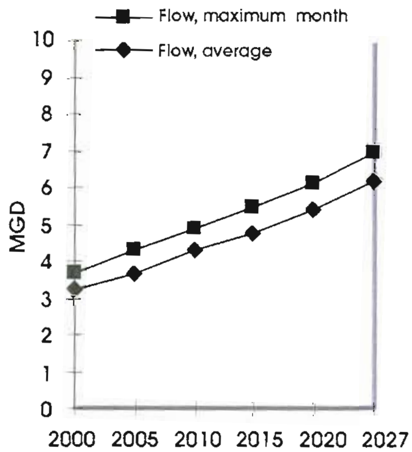


Figure 3-7
Projected Wet Season Industrial Flows



The following figures (Figures 3-6 through 3-9) show the projected industrial flows and loadings for the design period.

Combined Wastewater Projection

The following figures show the projected flows and loadings for all wastewater generated in the City's service area. The amounts include projections for domestic wastewater, industrial wastewater, and additional wastewater contributed by new industry that may move to the area in the next 30 years.

Figures 3-10 and 3-11 show that, although average flows are only slightly higher in the wet season than in the dry season, wet season peaks are much higher. Figures 3-12 and 3-13 reveal that loads to the treatment plant are noticeably higher in the dry season. November is a wet season month but still has significant industrial BOD loading; November's loading greatly increases the wet season average.

Figure 3-8
Projected Dry Season Industrial Loads

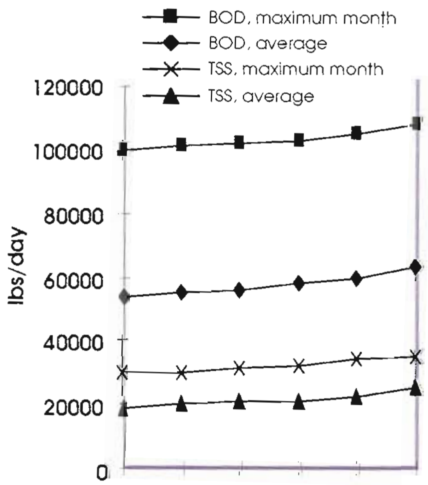


Figure 3-9
Projected Wet Season Industrial Loads

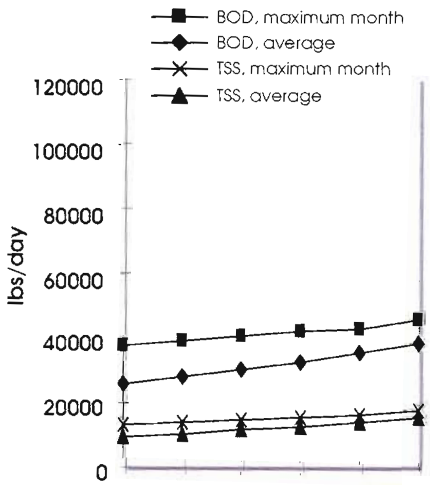


Figure 3-10
Projected Dry Season Domestic and Industrial Flows

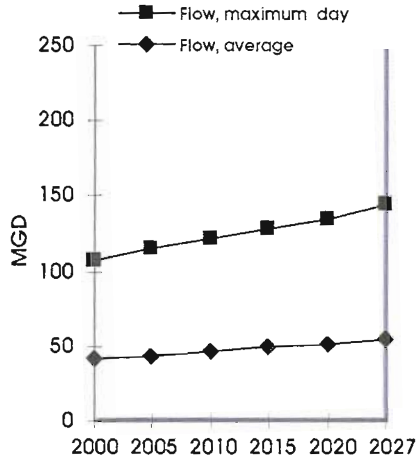


Figure 3-11
Projected Wet Season Domestic and Industrial Flows

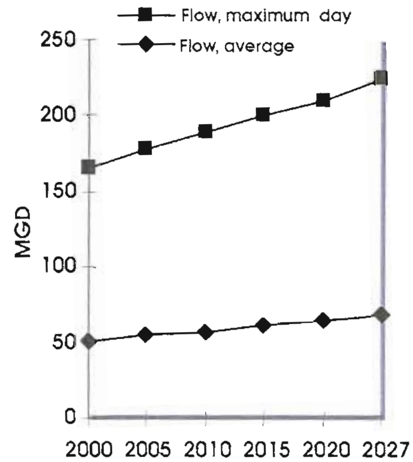


Figure 3-12
Projected Dry Season Domestic and Industrial Loads

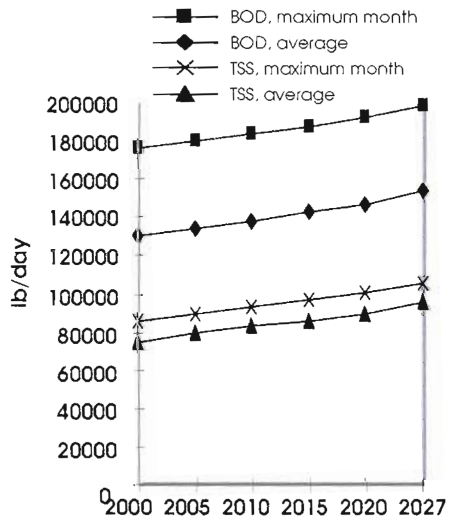
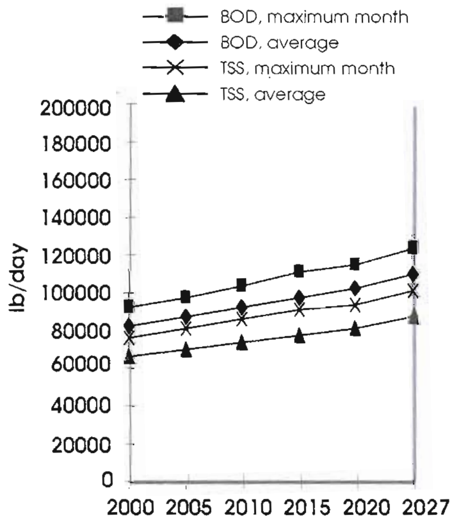


Figure 3-13
Projected Wet Season Domestic and Industrial Loads



SECTION 4

Permit and Treatment Requirements

The design and operation of Salem's wastewater infrastructure responds to many requirements that are intended to provide wastewater services while protecting the Willamette River, which receives the system's effluent. To form a basis for planning, system planners considered the quantity and characteristics of the wastewater (as discussed in Section 3), the current and anticipated permit requirements, and current Willamette Basin water quality standards. The system that will treat the projected flows and loadings in 2027 must, in the meantime, be approved by the Oregon Department of Environmental Quality (DEQ).

Current NPDES Permit Requirements

Regulatory compliance is the first step on the path to the City's goal of environmental stewardship.

The discharge of effluent to the Willamette River from the Willow Lake WWTP is controlled by a National Pollutant Discharge Elimination System (NPDES) permit, which expires on May 31, 1998. The provisions of the permit are summarized in Table 4-1 Two of the key measurements are BOD and TSS; the limitations on each are shown for the wet season and the dry season in Figures 4-1 and 4-2.

The NPDES permit also contains requirements concerning sanitary sewer overflows (SSOs; for more information see Sections 2 and 5). The permit requires that SSOs to tributaries of the Willamette River be eliminated by January 1, 1996, except for flows resulting from storms more severe than the 5-year 24-hour storm event. Also, a plan should be in place by January 1, 1996, to control SSOs to the Willamette River for storm events up to a 5-year event.

Figure 4-1
Current and Potential Future Dry Season Permit Requirements

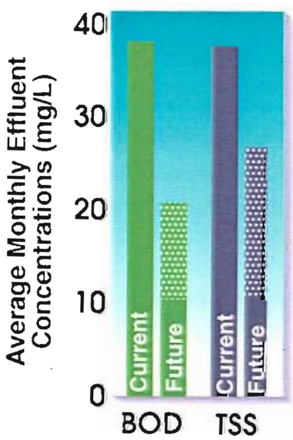
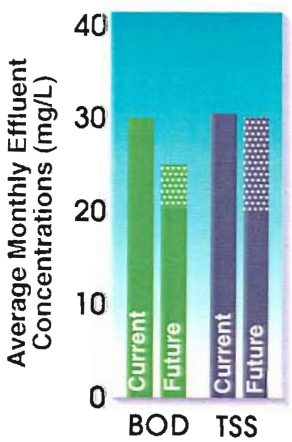


Figure 4-2
Current and Potential Future Wet Season Permit Requirements



The bars showing the future indicate a range for the requirements depending on future calculations of industrial allowance.

Anticipated Trends and Planning Assumptions

Potential Future NPDES Requirements

The City faces the following situation: continued discharge of treated effluent to the Willamette River will remain an important element of the wastewater management plan, and NPDES permit requirements for discharge to the river will tend to become more stringent. For example, the limits on the concentrations of BOD and TSS discharged in the future are expected to drop.

Table 4-1
Current NPDES Requirements

	Average Effluent Concentrations		Mass Load Limitations		
	Monthly (mg/L)	Weekly (mg/L)	Monthly Average (lb/day)	Weekly Maximum (lb/day)	Daily Maximum (lb/day)
June 1 through October 31					
BOD5[a]	37	45	11,000	13,000	15,000
TSS	37	45	11,000	13,000	15,000
FC/100 ml	200	400	NA	NA	NA
November 1 through May 31					
BOD5[a]	30	45	16,000	23,000	31,000
TSS[b]	30	45	16,000	23,000	31,000
FC/100 ml	200	400	NA	NA	NA

Other Parameters:
pH ....Shall be within the range 6.0-9.0
CBOD5, BOD5, TSS ...Removal efficiency shall not be less than 85% on a monthly average.
Total Residual Chlorine ....Shall not exceed daily maximum of 1.5 mg.
Mixing Zone ....Shall not extend beyond 150 feet radius of point of discharge.
FC ....Fecal coliform

[a] Permit is written for CBOD, which is 5 mg/L less than BOD.

Table 4-2
Potential Future NPDES Requirements

	Average Effluent Concentrations		Mass Load Limitations		
	Monthly (mg/L)	Weekly (mg/L)	Monthly Average (lb/day)	Weekly Maximum (lb/day)	Daily Maximum (lb/day)
June 1 through October 31					
BOD5[a,b]	10-24	15-28	11,000	13,000	15,000
TSS[b]	10-24	15-28	11,000	13,000	15,000
EC/100ml	126	NA	NA	NA	NA
November 1 through May 31					
BOD5[a,b]	20-30	30-45	16,000	23,000	31,000
TSS[b]	20-30	30-45	16,000	23,000	31,000
EC/100ml	126	NA	NA	NA	NA

Other Parameters:
pH ....Shall be within the range 6.0-9.0
CBOD5, BOD5, TSS ...Removal efficiency shall not be less than 85% on a monthly average.
Chlorine ....Shall not exceed daily maximum of 0.5 mg (unless supported in SSES studies).
Mixing Zone ....Shall not extend beyond 150 feet radius of point of discharge.
EC ....*Escherichia coli*

[a] Permit may be written for CBOD, which may be less than BOD as determined by the City and DEQ.

[b] Consists of Willamette River domestic BOD and TSS standards (10 mg/L in the dry season; 20 mg/L in the wet season) plus industrial allowance to be determined in the future.

Figures 4-1 and 4-2 compare the anticipated future BOD and TSS limits with the current limits. The bars showing the future indicate a range for the requirements depending on future calculations of industrial allowance.

For master planning purposes, wastewater system planners considered these possible factors to create a potential future NPDES permit (see Table 4-2):

- Basin standards of 10 mg/L of BOD and TSS during the period of May 1 through October 31 for domestic only. In addition, the permit provides for an allowance associated with the industrial load processed.
- Current state policy limits mass loads to existing levels unless significant financial impacts and no water quality impacts can be documented. Mass load increases must be approved by the Environmental Quality Commission (EQC).
- Toxicity issues may limit future ammonia discharge during low river flow periods.
- Phosphorus limits will not be imposed in the foreseeable future but the City should retain flexibility for implementation of phosphorus removal requirements.

- Chlorine effluent concentrations will be more restrictive than in the current permit.
- Effluent temperature and dissolved solids limits will not impact the selection and/or operation of liquid treatment processes.

Willamette Basin Water Quality Requirements

DEQ establishes the standards for river basins through Oregon Administrative Rule 340-41-445 and reviews them tri-annually. The following standards are included and are discussed in more detail in Appendix 4, *Projection of Treatment Requirements*:

- Dissolved oxygen
- BOD and TSS
- Temperature
- Turbidity
- pH
- Bacteria
- Dissolved gases
- Fungi
- Taste and odor
- Sediment
- Discoloration and scum
- Aesthetics
- Radioisotopes
- Total dissolved gases
- Total dissolved solids
- Toxic substances

Conditions of the Mutual Agreement and Order and Permit Modification

The purpose of the Mutual Agreement and Order (MAO) is to update and modify specific conditions and requirements of the City's current NPDES permit by incorporating the findings of ongoing engineering studies and analyses. The MAO also creates a framework within which the City and DEQ can work cooperatively and effectively to address permit conditions and water quality protection issues over the next 10 to 15 years.

The MAO outlines the conditions to be modified, the basis for modification, and the updated conditions and schedules for action and compliance. The subjects included in the MAO are listed below.

- Plan and schedule for elimination of tributary and Willamette River bypassing
- Inflow reduction
- Bioassays
- Toxicity and chlorine residual in treated effluent
- Willow Lake WWTP odor emissions
- Willow Lake WWTP effluent foam control
- Permit modification to adjust BOD and TSS removal requirement

Natural Treatment System Permitting Requirements

The recommended permitting approach for the natural treatment system (NTS, see Section 7, *The Preferred Treatment Alternative*) includes meeting with DEQ staff to discuss and agree on the technical design, treatment efficiency, and groundwater interactions. It is expected that the development of discharge standards will proceed in parallel with demonstration system design and implementation; some issues may be resolved only with site-specific data. The permitting approach for treatment plant discharges and NTS discharges needs to be pursued as a coordinated process, because of loading implications and the need for system flexibility. Should the City not receive a permit as planned, it must provide additional conventional treatment facilities at a higher cost as shown on Figure 6-1.

Permitting will address issues of discharge water quality, receiving water quality standards, groundwater protection, floodway encroachment, and resource protection and enhancement:

- Water quality requirements for water discharged from the Wetland Treatment System (WTS) depend on whether the water is to be discharged to the Willamette River via the outfall or to mitigation wetlands, and the season during which these discharges occur.
- Standards for discharge to the mitigation wetlands are not currently specified in any documentation or guidance from DEQ; therefore, they would need to be negotiated.
- Any potential groundwater impacts will also need to be reviewed with and agreed to by the DEQ.
- Marion County Zoning Ordinance Chapter 178 (Floodplain Overlay Zone) stipulates that floodplain encroachment will not result in an increase in flood levels for the base flood, which is the 100-year flood.
- Resource protection and enhancement are stipulated by modification No. 555 to the Marion County Zone Code (Greenway Ordinance). This code requires that areas of annual flooding be preserved in the natural state to the maximum extent practicable, and that land uses preserve and protect wildlife habitat and natural and cultural resources.
- It is possible that there are existing jurisdictional wetlands on the floodway site, which could trigger the need for a U.S. Army Corps of Engineers and Oregon Division of State Lands permit for fill and removal in wetlands; or the protection/mitigation of these wetlands.

SECTION 5

Wastewater Conveyance Strategy and Preferred Alternative

This section discusses the strategy used to develop plans for improving wastewater conveyance to the Willow Lake WWTP. The strategy employed alternatives evaluation, plan development, and project identification. The Plan was developed using proven methods for estimating the quantity of flow and modeling collection pipeline hydraulics so that present and potential future deficiencies of the conveyance system could be corrected. Maps of conveyance system improvements are included in the attachment at the end of this document.

Flow Characterization

The City's sewer system was divided into monitoring basins to assess the amount of rainwater and groundwater that is entering through leaking pipes (infiltration) or improper connections of stormwater sources (inflow). A total of 52 flow monitors were used (see Figure 5-1) to assess the amount of rainfall-dependent infiltration and inflow (RDI/I) resulting from four storms each year during 1993-94 and 1994-95. Seven categories were developed to rank the basins by priority for source detection activities and source reduction estimates based on the storm response analysis. Seven basins in 1993-94 and nine basins in 1994-95 had high infiltration and inflow. These basins were identified as having potential for cost-effective RDI/I reduction. Appendix 2, Section 1, of the support documents, contains detailed information about the flow characterization procedures and results.

Smoke Testing Program and Results

Seven basins with high RDI/I rates characterized as inflow basins were selected for smoke testing. The total area of these basins was 2,126 acres, but the smoke testing program focused on areas where defects were found to be the most concentrated; 711 acres were actually smoke tested. Approximately 143,000 lineal feet of pipe were tested, revealing 828 defects. The average concentration of defects per acre was 1.16, and 0.58 defects per 100 lineal feet of pipe, with the most common defect occurring within private service laterals.

The flowrate of water added to the conveyance system as RDI/I from these defects was estimated to be 1.6 million gallons per day. Possible rehabilitation procedures for remedying the defects include spot repair for sewer mains and service laterals, sealing and plugging defects within manholes, repairing broken plumbing on private property, redirecting downspouts, and reconnecting catch basins and drains to storm sewers. The total cost for repairs of defects was estimated at $2.25 million or $1.40 per gallon of RDI/I.

Dye Testing Program and Results

The dye testing program focused on Salem's downtown sector. Dye testing was performed on roof drains, area drains, and catch basins of sites with potential direct connections to the sanitary sewer. For those sites found to be connected to the sanitary sewer, the total drainage area tributary to the inflow locations was 3.35 acres. Of the 31 building roof drain systems tested in the downtown area, 13 were confirmed connected to the sanitary system. The majority are owned by the State of Oregon. Officials have been contacted and are evaluating and making plans to correct, as needed. Similar contacts will be made with the owners of other buildings.

Hydraulic Modeling

The portion of City of Salem's sanitary sewer system that is 12 inches and greater in diameter was hydraulically modeled using the XP-SWMM software based on inventory information from the City's Hansen maintenance management database and the geographic information system (GIS). The sewer system model estimated the wet season flows that would occur during storms of various sizes with current and future service area populations. A 5-year design storm flow model was developed, which compared closely to the measured flows resulting from a 5-year storm in February 1995. To evaluate conditions that result in basement flooding, a 25-year storm was developed. A detailed discussion of the hydraulic model development is contained in Appendix 2, Section 2, of the support documents. Based on the model developed and the calibration of the system that occurred, the model functions as a planning tool for future activities.

Development of Flows for Future Conditions

Population projections developed for the Salem area estimate a population of 254,000 in 2027 when the area within the urban growth boundary has been developed. Based on a forecast flow of 100 gallons per capita per day (gpcd), the estimated future domestic base flow rate is approximately 25.4 mgd. RDI/I from sources within the service area and from new service areas was added to the model as were flow projections for industrial growth. The estimated peak domestic RDI/I contribution per capita for future development is 400 gpcd for the 5-year storm, yielding a total peak flow rate of 500 gpcd. The projected future RDI/I rate is significantly less than the current rate. We assumed that new pipelines constructed using modern methods will reduce the RDI/I rate greatly. The assumed flow rates for future industrial developments varied depending on the type of industries projected to be built in each industrial zone with developable land. The details of the flow generation methodology are described in Section 2 of Appendix 2.

Model Results

The model was used to estimate what would happen during a 5-year storm if the existing pipeline system were not expanded or improved under two population conditions: today's service population of 170,000 and the projected buildout population of 254,000. Table 5-1 shows the results—overflows and flooding under current conditions with more locations and greater volume of overflows and flooding in the future.

TABLE 5-1
Modeled Overflow and Flooding with No Improvements to Collection System

	5-Year Design Storm	
	1995 Existing System	**2027 Existing System**
Overflows		
North River Rd. (MG)[a]	50	75
Union St. (MG)	30	40
Flooding		
Volume (MG)	25	35
Locations (number)	41	45
Potential Peak Flow Rate to Willow Lake[c] WWTP (mgd)[b]	155	155

[a] MG = million gallons; the total volume that overflowed or flooded during a single event.
[b] mgd = million gallons per day; the rate of flow at any moment.
[c] Limited to the hydraulic capacity of the existing conveyance system.

Improvement alternatives that eliminate flooding and overflows and convey the peak flow to the plant for the 5-year storm are described in "SSES

Alternatives Evaluation and listed in "Capital Improvement Program Identification."

SSES Alternatives Evaluation

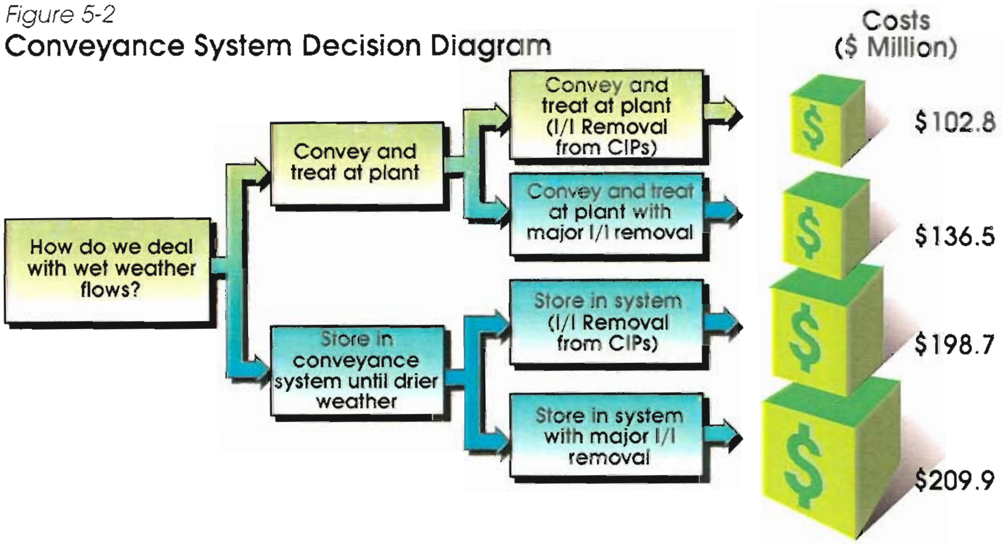
The Sewer System Evaluation Study (SSES) evaluated four wet weather control alternatives and developed a four-part ongoing RDI/I reduction program.

Development of Wet Weather Control Alternatives

The conveyance system capacity improvements were developed to meet the regulatory requirements for SSO control under buildout population conditions within the UGB. The SSES evaluation compared four alternative solutions to eliminate SSOs for up to the 5-year design storm:

1. Increase system conveyance capacity to carry peak flows to the WWTP without an aggressive RDI/I reduction program. The major conveyance element is a new interceptor from Union Street (downtown) to Willow Lake WWTP. This alternative would result in a peak hourly flow rate at the WWTP of 255 mgd and a peak daily flow rate of 225 mgd.
2. Increase system conveyance capacity to carry peak flows to the WWTP and pursue an aggressive RDI/I reduction program. This alternative is estimated to reduce peak flows to the WWTP from 255 mgd down to 250 mgd. The volume of peak flows delivered to the WWTP is less, but the peak hourly flow is only reduced by 5 mgd resulting in pipe conveyance requirements similar to Alternative 1.
3. Store peak flows greater than the current system peak conveyance capacity and release the water back into the system after peak flows have receded. The storage capacity was sized to be large enough for peak flow volumes where RDI/I was not reduced. The estimated storage capacity required is 115 million gallons.

Figure 5-2
Conveyance System Decision Diagram

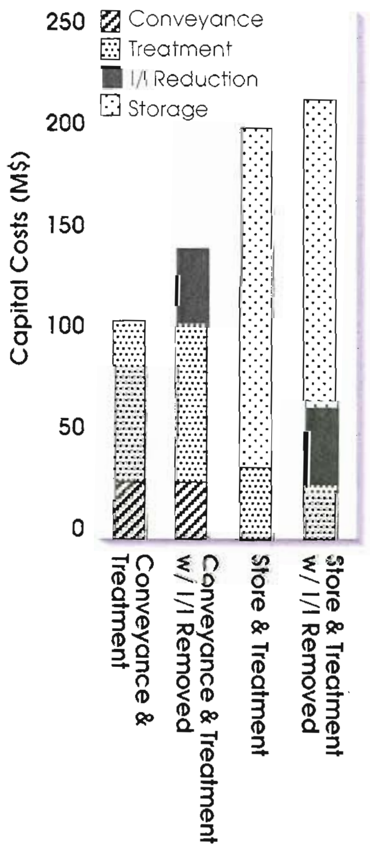


1. Store peak flows and pursue an aggressive RDI/I reduction program. This alternative resulted in an estimated storage requirement of 100 million gallons.

These alternatives were put through a decision process to determine their ranking as effective and low-cost solutions. Figure 5-2 diagrams that ranking process and shows the cost estimates used for evaluation.

Figure 5-3 graphs the relative costs for each alternative. Alternative 1, the convey and treatment solution, was selected as the preferred alternative as it had an estimated cost of $102.8 million, which is $33.7 million less than the next-lowest cost alternative. This total cost represents the cost associated with the collection system and with treatment components needed to hydraulically process the incremental increase in wet season flows over dry season flows. Dry season organic and hydraulic treatment costs are not included. These preliminary cost comparisons were generated as an evaluation tool and cannot be directly added to later costs estimated for various treatment alternatives.

Figure 5-3
Costs for Wet Weather Control Alternatives



Rainfall Dependent Infiltration & Inflow (RDI/I) Reduction Program

While the aggressive RDI/I reduction program estimated at $36.3 million was not a cost-effective solution to provide future conveyance system capacity, an RDI/I reduction program will still provide benefits to the City:

- Reduction of treatment costs at the Willow Lake WWTP
- Additional hydraulic capacity in the conveyance system

The RDI/I reduction program defined below will meet or exceed RDI/I increases from future pipe deterioration of the existing conveyance system and thus create greater capacity and increase the wet weather level of protection. The continuing RDI/I reduction program should consist of four components:

1. Eliminate known and identified connections between the sanitary sewer system and the storm drainage system.
2. Continue to use smoke and dye testing to identify high RDI/I contributors (connections) for cost-effective source control.
3. Use the ongoing perpetual life replacement program to correct deficiencies in drainage basins where high RDI/I flow rates have been identified.
4. Inspect all new construction to prevent improper connections and ensure that new conveyance facilities do not provide new sources of RDI/I.

Capital Improvement Program Identification

Capital improvement program (CIP) projects were identified that increased the capacity of the conveyance system to meet the requirement that no SSOs occur in the system through the 5-year storm event and reduction of basement flooding (see Table 5-2). This table lists only those conveyance system projects needed to eliminate SSOs and does not include the perpetual life program or treatment-related projects.

TABLE 5-2
Proposed CIPs for City of Salem Sanitary Sewer System

Project	Order-of-Magnitude Cost[a] (1995 Dollars)
CIPs Needed Under Current 5-Year Storm Peak Flows	
1. Madison Street Bypass Line	$1.3 million
2. Pringle Creek Basin Trunk Replacement	$1.6 million
3. Clark Creek Basin Trunk Replacement	$2.5 million
4. Fairmont/Nob Hill Partial Trunk Replacement	$0.3 million
5. Edgewater Street Trunk Replacement	$0.8 million
6. Gerth Avenue NW Trunk Replacement[b]	$0.3 million
7a. Battle Creek Pump Station Capacity Increase	$1.6 million
7b. Battle Creek P.S. Parallel 20-inch Force Main	$0.5 million
8. Church Pump Station Capacity Increase	$0.4 million
9. Mission Pump Station & FM Capacity Increase	$1.5 million
1 through 9 Subtotal Cost	**$10.8 million**
10. West Salem Trunk Sewer	Construction completed in 1995
11. South River Road Trunk Replacement	Construction completed in 1995

Project	Order-of-Magnitude Cost (1995 Dollars)
CIPs Needed Under Buildout 5-Year Storm Peak Flows	
12. Alexander Pump Station Capacity Increase	$0.5 million
13. Chemawa Pump Station Capacity Increase	$0.7 million
14. Walnut Creek Basin Partial Trunk Replacement	$0.2 million
12 through 14 Subtotal Cost	**$1.4 million**

Project	Order-of-Magnitude Cost (1995 Dollars)
CIPs Needed to Eliminate Willamette River SSOs	
15. West Salem Pump Station Capacity Increase	$2.7 million
16a. Airport Pump Station Capacity Increase	$3.6 million
16b. Airport Diversion Line	$0.9 million
16c. Parallel 36-inch Force Main to ES Interceptor	$1.7 million
17. Miscellaneous	$0.2 million
18. Union Street to N. River Rd. Interceptor	$6.1 million
19. N. River Rd. P.S. & Force Main to WWTP	$18.6 million
15 through 19 Subtotal Cost	**$33.8 million**
Grand Total All Proposed CIPs	**$46.0 million**

[a] ENR construction cost index for the Northwest (October 1995) = 5,934.
[b] Project identified through the modeling of a portion of the pipe system less than 12 inches. No other areas with pipes less than 12 inches were modeled and this table does not reflect other potential capacity deficiencies in the unmodeled system.

These projects consist of:

- Replacing pipes with larger ones
- Constructing diversions within the system to make use of existing capacity
- Increasing capacity at selected pump stations
- Diverting additional flow to the East Salem Interceptor which requires increasing the capacity of the Airport Pump Station and the force main to the interceptor
- Constructing a new gravity interceptor from the Union Street overflow structure to the North River Road Park overflow structure
- Constructing a new pump station at North River Road Park and a 54-inch force main from the park to the wastewater treatment plant via West Salem requiring two Willamette River crossings

The total order-of-magnitude cost for the nine local CIP projects and the major conveyance system improvements is $46.0 million.

Perpetual Life Program

The perpetual life program will be continued by the City of Salem to identify and replace pipe segments or lift stations within the conveyance system that have reached their service life. The following summarizes the approach to identifying pipe replacement sections:

- Perform video inspection of the pipeline system and use previously videotaped information to assess physical condition.
- Use the City's database to estimate the average age of pipe in each drainage basin.
- Assess the level of RDI/I in the drainage basins using flow monitoring data.

Replacing pipes that are reaching the end of their service life avoids pipe collapse and reduces RDI/I in the system. As the program name indicates, this identification and replacement program will be a continual program conducted by the City to maintain operational capability and ensure sufficient hydraulic capacity of the sanitary sewer system in the future.

In general, a sewerline has a life of approximately 75 years. Therefore, approximately 1.33 percent of the system should be replaced annually, unless the system is in below average condition, in which case an increased level of replacement would be appropriate. Also, preventative maintenance of the conveyance system, such as line repairs, root treatment, cleaning, pump station maintenance, is in addition to the proposed perpetual life program.

This plan recommends a $2.5 million annual perpetual life program beginning fiscal year 1998-99.

SECTION 6

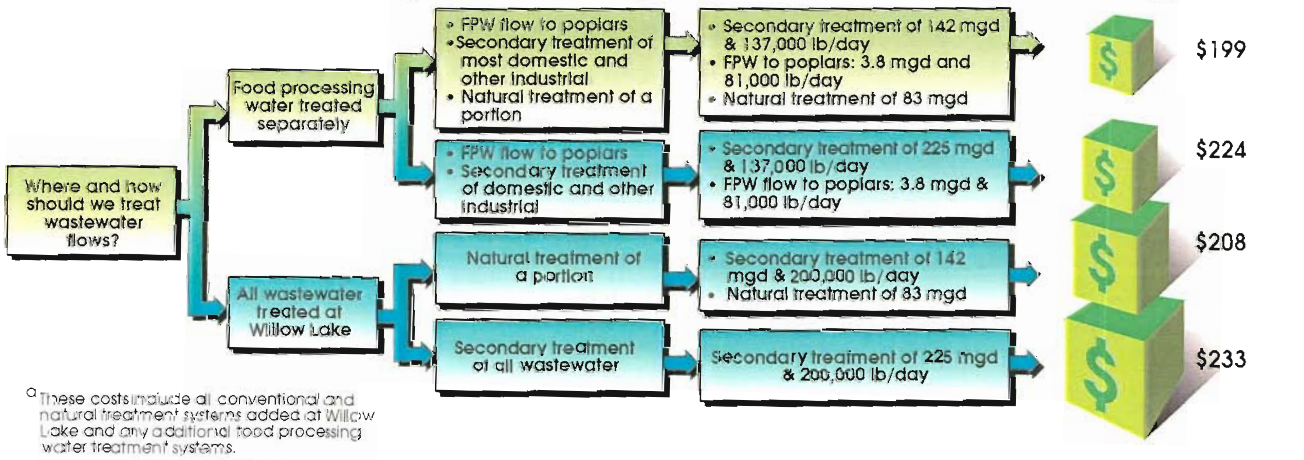
Wastewater Treatment Strategy

In developing a treatment strategy, planners assembled a wide range of alternatives, screened out several unlikely ones, and arranged them in priority order using the same decision process used in the conveyance strategy. Figure 6-1 represents the process, with the preferred alternative shown at the top of the figure. As with the conveyance process, should the preferred alternative not be implementable, planners can move back down the process and start to develop another alternative.

Planners created a total of 27 alternatives for initial screening, 18 of which were evaluated further and finally reduced to the combination of four shown in Figure 6-1. This section describes that process. A detailed description of the evaluation process is included in Appendix 6, *Identification and Screening of Treatment, Reuse, and Discharge Alternatives*, of the support documents.

Figure 6-1
Treatment System Decision Diagram

1995 Capital Costs[a]
($ Million)



[a] These costs include all conventional and natural treatment systems added at Willow Lake and any additional food processing water treatment systems.
Costs do not provide for conveyance system improvements or additions.

Development of Alternatives

To develop treatment alternatives that are effective and cost as little as practical, wastewater system planners examined the existing facilities at the Willow Lake WWTP, the quantity and character of the wastewater, and the water quality requirements. The alternatives needed to answer three key questions:

- How shall we continue to treat food processing water (FPW)?
- How shall we increase treatment capacity?
- How shall we dispose of, or reuse, effluent?

Each of the key questions had three possible answers, which became the criteria for further analysis:

- **Treatment of Food Processing Water**
  - *Separate treatment.* FPW from four of the major processors will be collected and transported to a separate land-application treatment system during the dry season. Dry season flows and loads requiring treatment at the treatment plant are reduced by the amount transported to the land-application system.
  - *Pretreatment.* FPW from the four selected processors is collected and transported to a covered anaerobic lagoon treatment system. Effluent from the pretreatment system is returned to treatment plant.
  - *Treatment of full load at the treatment plant.* FPW from the four selected processors are collected and transported in the existing system for treatment at the treatment plant.
- **Treatment Capacity Increase**
  - *Expansion at Willow Lake.* Staged construction of additional facilities on the existing Willow Lake site.
  - *Complete new plant.* Staged construction of a new treatment plant, phase out of the existing plant.
  - *Combination of expansion and new plant.* Continued use of the Willow Lake Facility plus construction of a separate plant.
- **Effluent Discharge**
  - *Year-round discharge.* Year-round discharge of all effluent to the Willamette River.
  - *Partial summer reuse.* Implementation of a reuse network capable of reducing the summer discharge to the river up to 50 percent and of reducing the need for expansion of facilities at the treatment plant.
  - *Full summer reuse.* Implementation of a reuse network capable of reducing the summer discharge to zero.

The combination of these criteria yields a total of 27 basic alternatives. Rather than estimate costs for all alternatives, costs were not developed for alternatives involving a combination of Willow Lake expansion and a new plant. Costs for these alternatives are almost certain to fall between the costs of corresponding alternatives involving either an expansion or a new plant. Thus, 18 alternatives were evaluated for cost.

Evaluation of Alternatives

A comparison of capital costs for treatment, reuse, and discharge alternatives was performed using a spreadsheet cost comparison process. The comparison included costs for treatment and discharge (but not conveyance) at a wastewater treatment plant (either Willow Lake or a new plant) plus the cost of collection, conveyance, treatment, and discharge of major food processing wastes where handled differently. The basis of the evaluation was relative capital costs only.

The methodology used to determine the capital cost for an alternative was as follows:

- Identify flow and loads required for WWTP treatment. Maximum month canning season loadings for year 2027 are considered.
- Apply standard engineering assumptions on process performance to size the required treatment processes.
- For alternatives involving expansion at Willow Lake, for each unit process, subtract the estimated useful capacity of existing facilities at the plant to determine the capacity required for construction.
- Use a treatment unit cost database (derived from analysis of costs for similar, recently constructed, CH2M HILL-designed treatment units) to estimate costs of required additional facilities. Include renovation cost factors to reflect the increased cost of supplementing or rehabilitating existing treatment units for use in treating future loads through the project life (year 2027).

The costs derived from this method are only for comparison among alternatives; they are not intended to represent, with a high level of accuracy, the actual capital cost of constructing the final treatment system. To obtain a budget level capital cost estimate, we must select a preferred alternative and perform a preliminary facility plan analysis.

Conclusions and Recommendations

Cost Comparison

The cost comparison shows that alternatives based on separation of FPW for land application on a poplar plantation (as described in Section 7) have a significantly lower cost than alternatives based on full treatment of those loads at the WWTP (see Table 6-1). The low end of the cost range includes the less costly options of expanding and upgrading the treatment plant and partially reusing effluent. The high end of the cost range includes the more expensive options of building an entirely new plant and reusing all effluent.

TABLE 6-1
Comparison of Capital Cost Ranges[a]

Set of Alternatives	Low Capital Cost[b] Ratio	High Capital Cost[c] Ratio
Separated FPW	1.0	3.2
Untreated FPW to WWTP	1.3	3.5

[a] Cost comparisons are presented as the ratio of each alternative's cost divided by the cost of the least-cost alternative.
[b] Existing plant with partial reuse.
[c] New plant with total reuse.

Reuse Options

Partial summer reuse options include irrigation of hybrid poplars with disinfected secondary effluent, which then flows into treatment wetlands. A partial summer reuse program cannot be completely evaluated at this time because it requires data from a 5-year demonstration to determine design parameters and effectiveness. It appears, however, that the use of a natural treatment system is the best alternative. That system, which is described in Section 7, would also treat excess wet season flows, following primary treatment and disinfection, and would polish and reuse peak secondary-treated flows during the dry season. Reuse of the polished dry season flow will always include supplying the proposed mitigation wetlands. The reuse program will be expanded to include other reclaimed water uses as markets are developed.

Depending upon the success of demonstration projects, the natural treatment system could be expanded in the future, reducing the requirements for future mechanical treatment and outfall facilities.

Willow Lake WWTP Expansion

Even with a natural treatment system consisting of a poplar plantation and wetlands treatment, the Willow Lake plant will need to be expanded and upgraded. The cost comparison indicates that the best alternative for more detailed definition and cost development is the alternative described as "FPW separated, expansion at Willow Lake, year-round effluent discharge."

Should it be necessary to further develop another appropriate but more costly alternative, contingency planning and cost estimating have been done for other alternatives, which are described in Appendix 7, *Evaluation of Final Treatment Alternatives*, in the support documents.

We also recommend that development of the alternative include demonstration of an integrated poplar plantation and wetlands system to reduce future Willow Lake treatment plant needs, improve plant operations, reduce loads to the Willamette River, and beneficially reuse effluent.

SECTION 7

The Preferred Treatment Alternative

The process described in Section 6 resulted in the identification of a preferred alternative for treatment that involves three main components:

- Land application of separated food processing water on a poplar tree plantation
- Expansion and upgrading of the conventional secondary treatment processes at the Willow Lake WWTP
- Establishment of a natural treatment system at the Willow Lake site to complement conventional secondary treatment

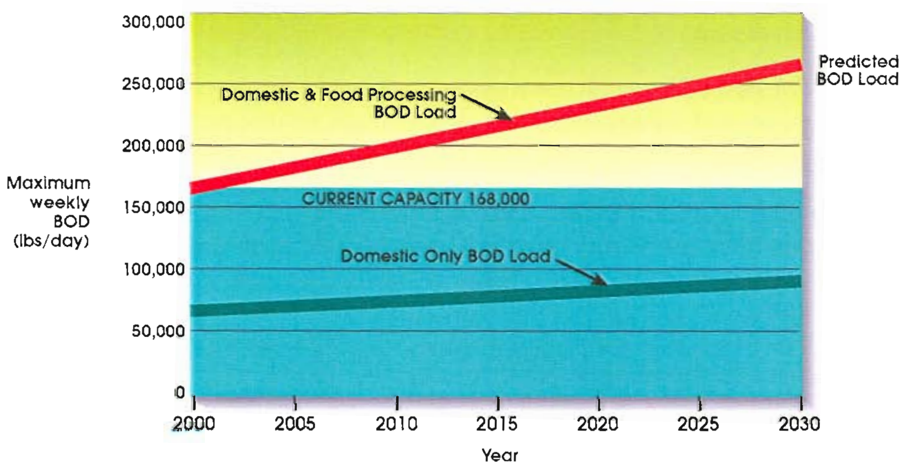
Treating Food Processing Water

The thriving food processing industry is a key contributor to the economy of the Salem area. The processors' high-strength wastewater and seasonal operation, though, provides a challenge for the managers of the wastewater system.

The wastewater from the processors is not the same as domestic sewage that comes from residences. It contains high concentrations of dissolved food and suspended fruit and vegetable fragments. This translates into very high levels of organic content, or BOD. The BOD of the food processing water (FPW) can exceed that of domestic sewage by a factor of ten.

In addition, this flow comes at harvest time: in the summer and early fall, when the river levels are low and the discharge permit requirements are strict. Treating the FPW to the stringent levels required at this time of

Figure 7-1
Total Predicted BOD Loading/Plant Capacity



year is very expensive, and increasing flows in the future would require costly upgrades at the Willow Lake plant.

Land Application of FPW

The master plan calls for implementation of an innovative and natural treatment process, one which provides a comprehensive solution. Rather than treating the FPW in the same manner as domestic sewage, for which destruction of pathogens is a concern, the pathogen-free FPW will be separated and treated in a simpler, cheaper way: it will be applied to a poplar tree plantation. In this way, the nutrient (food) value of the FPW is recovered as a resource, not mechanically and biologically treated as a waste. Also, the need for costly upgrades at the Willow Lake plant is postponed and reduced. Furthermore, the poplar plantation provides environmental and economic values by substituting a different wood fiber than obtained from trees cut from forests and by providing attractive wooded cover adjacent to Salem.

A poplar plantation not only treats FPW, it provides environmental and economic value.

So that the FPW never mixes with domestic sewage, a completely separate conveyance system will be built to carry it from the processors to the poplar plantation. Then, an irrigation system will apply the FPW to the poplars, which will use both the nutrients and the water. When the trees have grown for 6 to 8 years, phased cutting and replanting will begin, producing wood suitable for paper production.

This treatment method is similar to application of FPW to field crops, a well-established process around the country, but application to poplars provides several advantages:

- Poplars can consume a large amount of water late in the growing season when treatment capacity is needed most.
- Phased harvests minimize interruption of the plantation's treatment capacity.
- Poplars provide a deep, stable root zone for treatment of organic and mineral constituents of FPW.
- Poplars tolerate a wide range of soil moisture and chemical conditions.
- Irrigation and monitoring equipment doesn't need to be designed to accommodate frequent field operations such as tilling, planting, and harvesting.
- Poplar fiber is in increasingly high demand for use in production of white paper and, as a result, has become a high value commercial crop serving a growing market.

Several of these technical advantages combine to create a soil layer where applied FPW is not only treated but can also be managed as a regulating reservoir, reducing the need for construction of costly storage ponds or tanks.

Development of a Land Application Site

SITE SELECTION

The first step in development of this treatment option is to locate a suitable site. Several sites have been studied, but for planning purposes we have used approximately 640 acres at the northern end of the Hayden Bottoms area located southwest of Salem. This site has larger fields and more suitable soils than other sites studied. Drainage and soil conditions should be investigated in detail as an initial step for land application system predesign.

LAND OWNERSHIP/LEASING

There are four land ownership or leasing options for the future land application site:

- A farmer owns the land and contracts with the City to manage the land application system.
- A farmer leases the land and contracts with the City to manage the land application system.
- The City leases the property, with the lease specifying its use as a land application site.
- The City purchases the property.

Since discussions with owners of potential sites are pending, all four options remain under consideration to provide the City and landowner needed flexibility.

Design of the Land Application System

DESIGN CRITERIA

The purpose of the land application system is to treat FPW, not to grow poplar trees.

The basic design criterion is that the system must reliably treat the expected FPW flows. A reliable system must meet the following specific criteria:

- Complies with Oregon guidelines for land application of industrial wastewater, including nondegradation of groundwater
- Conveys, distributes, and applies design flows on the land application site
- Establishes and maintains a healthy poplar stand and soil conditions that promote sufficient water uptake and treatment so that odors are controlled and groundwater is protected
- Provides sufficient monitoring, control, and maintenance so that operators can reliably manage the flows

More specific design criteria and other considerations are discussed in Appendix 8, *Industrial Waste Treatment*, of the support documents, including:

- Pertinent regulations
- FPW quality and quantity
- Willow Lake treatment plant load limitations

- Costs
- Conveyance requirements
- Plant, soil, and water conditions at the site
- Irrigation system
- Monitoring requirements

Schedule

To avoid early construction of major improvements at Willow Lake, the FPW land application system needs to start operating as soon as possible. To determine that date, designers looked at how much water the trees can use as they grow from seedlings to maturity. After 3 years, a plantation of 640 acres will be able to treat the design flows expected from the four identified industrial users. An irrigation system will be necessary for establishing the poplar plantation, and existing irrigation water rights can be used. In the meantime, construction of pumps and pipelines to deliver FPW to the site can be completed.

In order to spread capital cost burden over time, current plans are to construct a first phase with capacity to treat FPW from the Agripac 1 plant located on the west side of the Willamette River. The second phase would tie in Truitt Brothers, Agripac No. 2, and Oregon Cherry from the east side.

Site Operation and Maintenance

As with land ownership, there are alternative ways to operate and maintain the site:

- A farmer operates and maintains a farming enterprise (replanting, fertilization, weed control, day-to-day irrigation, harvest and marketing of poplar trees) and monitors the system with the City (soil, groundwater, and plant growth). The City funds site improvements and initial tree establishment and reimburses lost revenues to farmer.
- City operates and maintains entire site.

Combining the ownership and O&M options produces the following alternatives.

TABLE 7-1

Management Alternatives for Land Application Facility

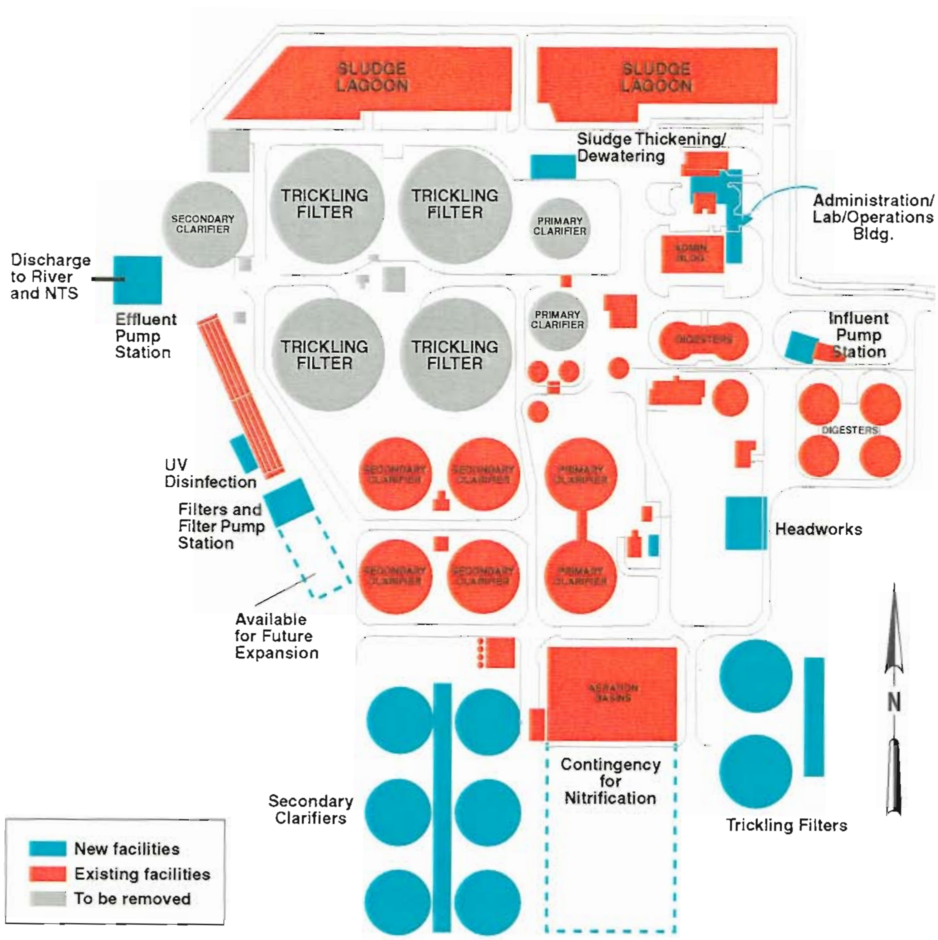
Alternative No.	City Land Tenure	Operator
1	Agreement	Farmer
2	Lease	Farmer
3	Lease	City
4	Ownership	City

Planting and managing a poplar plantation will be a significant change in a farmer's cropping pattern and cash flow compared to the current farming operation. For example, no revenues from the sale of trees would be available until the first harvest year, about 6 to 8 years after planting. To motivate the farmer to operate and maintain the farm as a land application system, therefore, it would probably be necessary to provide an income equivalent to that generated by the current farm. If the City operates and maintains the site, it would pay the O&M costs. These assumptions are the bases for future economic analyses, which compares the costs of alternatives involving O&M by the City or by the farmer.

The alternatives for land ownership and O&M all result in a total present worth cost of about $30 million for the land application system, including $15.3 million in capital cost. The land application capital costs compare favorably with the approximately $25-million capital cost of WWTP improvements needed to perform a similar function with an associated present worth of $38 million. Perhaps more importantly, Willow Lake WWTP improvements to accommodate all FPW would require $186 million (even with the NTS) and would have to begin immediately.

Treatment Facilities at Willow Lake

Figure 7-2
Willow Lake WWTP Site Plan, 2027



A Combination of Systems

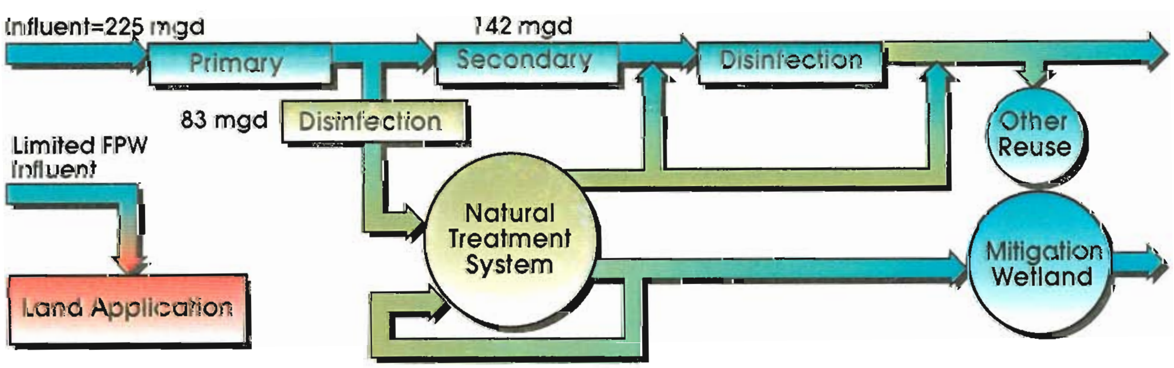
Wastewater system planners have evaluated a combination of treatment systems to provide the needed treatment capacity and effectiveness at the Willow Lake WWTP site through the design period. The plan combines improvements and expansion of conventional treatment processes with the construction of a natural treatment system using wetlands and poplar trees. In 2027, at the end of the design period, this combined system will have the flexibility to treat the highest projected flows and loadings. The plant upgrades and new processes (see Figure 7-2) will be phased in over the next 15 years, resulting in three key benefits to Salem area residents: capital costs will be spread over a longer period, treatment will continue to be effective at all times, and the discharge of treated wastewater into the Willamette River will be minimized.

Process Flexibility

The secondary treatment processes at the plant will be designed to treat the highest daily wastewater flow of the dry season in 2027—142 mgd. Other flow conditions need attention, however. The highest anticipated flow for any day in the wet season is 225 million gallons. The additional amount of flow (83 mgd) comes from rainwater that infiltrates or inflows into the sewer system. The headworks, primary treatment, and disinfection facilities will be designed to handle the full 225 million gallons.

Construction of secondary treatment facilities for the entire flow would be very expensive, and they would be fully used only on the wettest days of the wet season. Therefore, in the proposed alternative, flow greater than 142 mgd will be diverted after primary treatment and disinfection to the natural treatment system (NTS), a less costly method of providing treatment capacity for these rare events. The greatest amount of diverted flow is projected to be 83 mgd, so the NTS has been designed to handle up to that flow rate. Figure 7-3 shows the process flow under the highest flow conditions.

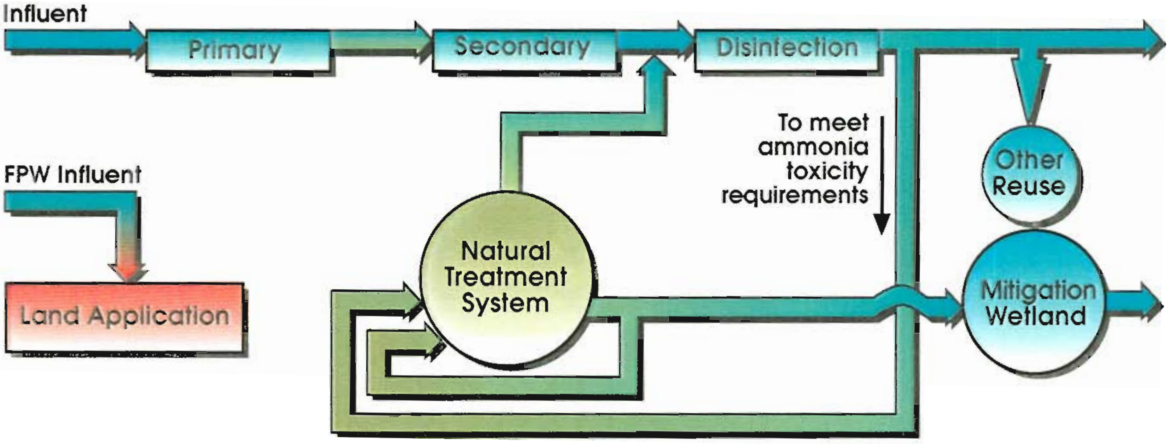
Figure 7-3
Process Flow with Maximum Day Flows in 2027



A different yet still crucial situation may occur in the dry season by the end of the design period. When the Willamette River flows are at their lowest, the water temperature tends to be at its highest. Residual ammonia in the treated effluent becomes more toxic as temperature rises and may cause the ammonia level in the Willamette River mixing zone to rise above water quality standards.

Construction of conventional treatment facilities to reduce the ammonia to meet potential future permit requirements when the river flow is low would be very costly. But routing a portion of the effluent through the NTS will reduce the ammonia level, again at less cost than for additional conventional treatment facilities. Depending on conditions, three options are available: the effluent could remain in the NTS until ammonia concentrations are acceptable, the NTS effluent can be discharged with other plant effluent after plant flows decrease, or a portion of the NTS effluent could be routed back through the plant for further treatment. The NTS, then, serves as both a treatment process and as a storage reservoir to provide further treatment flexibility. Figure 7-4 shows the process flow for the dry season, indicating the use of the NTS for ammonia removal.

Figure 7-4
Process Flow in Dry Season



The Natural Treatment System (NTS)

The NTS provides high-quality, cost-effective treatment for regulatory compliance and operational flexibility under many flow and loading conditions. It treats wastewater by using naturally occurring processes of plants and microbes but in a planned and controlled system. The NTS consists of two subsystems: the overland flow system (OFS) and the wetlands treatment system (WTS).

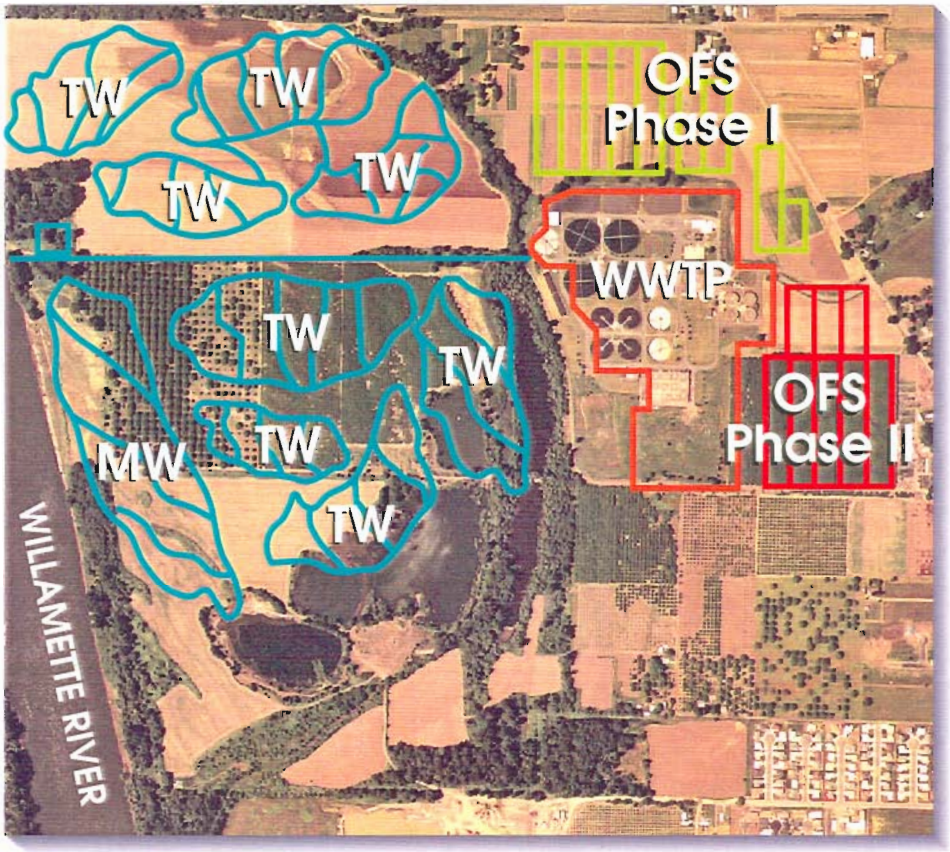
The objectives of the NTS are to provide:

- Treatment of disinfected primary effluent when winter treatment plant flow exceeds 142 mgd
- Treatment of secondary treated and disinfected effluent when summer treatment plant flow exceeds 50 mgd and/or when ammonia toxicity becomes an issue
- An equalization basin if temporary effluent storage is needed before discharge to the Willamette River or for recycle for additional treatment
- A viable reuse option
- A source of water for mitigation wetlands
- Restoration of wetlands and wildlife habitat
- The opportunity for educational and recreation benefits

- A "green" treatment alternative

The most promising site for the NTS is adjacent to the WWTP. The OFS would cover at least 40 acres adjacent to the WWTP, and the WTS would cover about 230 acres to the west. The locations and sizes of the areas are shown on Figure 7-5.

Figure 7-5
Natural Treatment System Conceptual Layout



TW= Treatment Wetland
MW=Mitigation Wetland
OFS= Overland Flow System
WWTP=Wastewater Treatment Plant

THE OVERLAND FLOW SYSTEM (OFS)

The OFS will provide treatment of wastewater flows before they enter the WTS thus reducing the area required for the WTS. It will remove or transform BOD, TSS, phosphorus, and ammonia. The OFS will be a series of strips of land, sloped and perhaps enriched with fine-textured surface soil to provide adequate runoff without excessive infiltration. The area will be planted with a mix of grass and poplar trees, the former providing filtration and holding soil in place, the latter penetrating the soil to greater depth, increasing the capacity to hold and treat the constituents of the wastewater within the soil. The entire OFS will be surrounded by buffer areas of densely planted poplar that will be irrigated with disinfected secondary effluent.

WETLAND TREATMENT SYSTEMS (WTS)

Wetland systems, both natural and constructed, have demonstrated water quality benefits for more than 50 years. There are currently over 200 systems operating within the United States, with additional hundreds operating in Canada, Europe, and other foreign countries. A constructed wetland allows regulation of the depth of water and the time it resides in the system, two of the most important factors in determining the extent of water treatment.

The wetlands treatment system will restore wildlife habitat and provide recreational and educational benefits.

In order to accomplish treatment objectives, the WTS would cover approximately 184 acres of wetted area, with an additional 46 acres in berms, buffers, and access roads. This acreage would be sectioned into 8 cells of approximately 23 acres each, in two parallel series to allow for maintenance and improve flow distribution and control. The downstream cells would be somewhat irregular in shape, as each subsequent cell in the sequence is designed to promote a higher frequency and diversity of wildlife use. Buffers would be planted with native trees and fast-growing poplars. The water depth in the wetlands would average approximately 2 feet, with deep water areas (to 8 feet) running crosswise to the flowpath to allow even distribution of flow. The area of deeper water would increase in the final cells, for temperature control during the summer months.

Vegetation would cover approximately 75 percent of the cell areas early in the flowpath, with cover in downstream cells approaching 50 percent. The final cells would have nearly 100 percent cover, except for the deep water areas. Cattails and bulrushes would be the predominant plants in the initial cells, with more diverse communities of plants tolerant of shallower water depths that provide more wildlife benefits found in the downstream cells.

Next to the WTS will be an 80-acre wetland created to provide the City with wetland mitigation credits to offset potential wetland impacts from other public works projects. The mitigation wetland will receive the high-quality effluent from the WTS. It can provide wildlife, recreation, and education benefits, and would approximate presettlement Willamette Valley wetland conditions.

Upgrades and Expansion of the Wastewater Treatment Plant Facilities

To accomplish the plan for a combined conventional and natural treatment system, the existing Willow Lake WWTP will be expanded to provide primary treatment (pumping, screening, grit removal, and disinfection) for a maximum day flow of 225 mgd. The plant will provide secondary treatment for a maximum day flow of 142 mgd.

The plant modifications include replacement of the existing 105-mgd influent pump station and a new primary treatment facility for a flowrate of 225 mgd. The primary treatment facility will include fine screens (1/4-inch openings) and swirl-type grit removal basins. The screenings will be compacted to remove water and reduce their volume before incineration or landfilling. The grit will also be washed and dewatered for incineration and landfilling. The primary treatment facility will be enclosed and odor scrubbed.

The two existing north plant primary clarifiers, which are over 30 years old, will be abandoned. The two south plant primary clarifiers will be rehabilitated to provide continued future service. Two existing south plant secondary clarifiers will be converted to primary clarifiers to replace the abandoned north primary clarifiers. No new primary clarifiers are planned.

The trickling filter/activated sludge process has been selected to provide secondary treatment at the plant. Two new trickling filters will be constructed to the east of the existing aeration basins. The trickling filters will have plastic cross-flow media and covers for odor control. The existing aeration basins will provide adequate aeration, so no new aeration basins are planned. The existing basins will be rehabilitated as necessary to provide future service.

Six new secondary clarifiers will supplement the remaining two existing secondary clarifiers. The clarifier construction will include new return sludge pump stations and piping galleries.

A new ultraviolet (UV) radiation disinfection facility will treat flows up to 142 mgd. Flows in excess of 142 mgd will receive chlorination/dechlorination after being processed in the natural treatment systems. A 3-mgd filtration facility will provide additional treatment for onsite irrigation and other reuse programs. Final plant effluent will be discharged to the Willamette River through a new diffuser pipe and/or the mitigation wetlands.

The Willow Lake solids processing facilities will include a new sludge thickening and dewatering facility. Two gravity belt thickeners will thicken the waste secondary sludge prior to anaerobic digestion. Primary sludge will be thickened in the clarifiers or gravity thickeners.

One existing secondary digester will be converted to a heated and mixed primary digester. The existing seven digesters will be adequate. No new digesters are planned, although all digesters will require mechanical rehabilitation. Once sludge is stabilized it becomes "biosolids."

Biosolids dewatering by centrifuge or belt press will be added to provide sludge reuse flexibility. Biosolids cake can be hauled to local farmers or to eastern Oregon for reuse during the wet season when biosolids are difficult to land apply in the Willamette Valley.

SECTION 8

Plan Implementation

Project Phasing

The Salem Wastewater Management Master Plan represents a major investment by the City to protect the environment and efficiently manage and treat wastewater. To implement the plan, the City must ensure that funding is available when needed. It is not necessary or desirable—or even possible—to complete all the projects in the plan immediately. The proposed timeline for project staging is presented in Figure 8-1.

There are several reasons to complete the projects in phases, which will spread out the costs. First, phasing projects will prevent abrupt rates increases, never popular with the utility ratepayer or the City. As customers see the benefits of early projects, they will be more likely to support subsequent bond issues. In addition, deferring projects allows people and industries who arrive in the future to help pay their own way.

Planning the funding enables the City to responsibly implement the Plan over time.

A final and critical reason for phasing: some of the project processes, such as the FPW treatment and the NTS, are innovative and will require a demonstration phase to fully determine their capabilities. These processes can be adjusted during the demonstration phase before costs are very high. Fortunately, the demonstration phase elements serve as foundations for the full-fledged systems and will become part of the completed projects. Most importantly, the degree to which the demonstration phases succeed directly impacts the nature and extent of conventional treatment works to be constructed at Willow Lake.

Figure 8-1
Project Staging

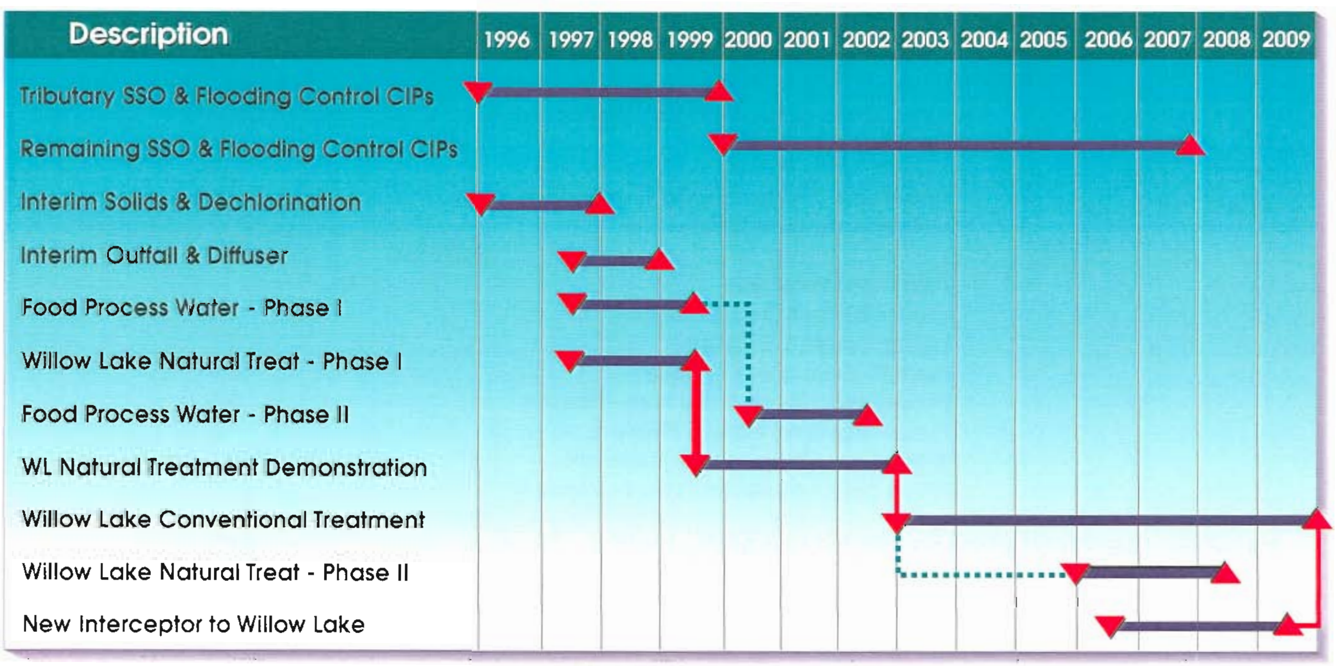


Figure 8-1 currently shows some of the highest priority projects being the conveyance projects that will end manhole and basement flooding under current land use conditions during a 5-year storm event. These projects will solve a serious environmental problem rather quickly.

The interim solids and dechlorination projects are top priorities to improve the Willow Lake WWTP's ability to function properly. Interim solids management is needed to avoid problems resulting from limits on the ability to remove and reuse excess biosolids. Dechlorination will reduce the possibility of toxic amounts of chlorine harming plant and animal life within the mixing zone in the Willamette River.

Another interim project required at the Willow Lake WWTP that bears directly on receiving water quality is the interim outfall and diffuser. This project is scheduled for early implementation to improve the dilution of treated effluent within the mixing zone .

The first phases of the FPW and the NTS round out the projects that require rapid implementation. The final configuration and optimization of other treatment projects are, in fact, dependent upon the results of phase I of the FPW and NTS projects. That is, the exact nature and size of each successive project will depend upon the measured performance of these first two pivotal projects.

The most significant costs will be for treatment upgrade and expansion at Willow Lake. Final capital costs of these facilities will depend heavily upon the success achieved with the FPW and NTS projects.

Project Capital Cost

Table 8-1, Capital Cost Estimate, lists estimated capital costs for projects included in the master plan. The costs listed are in 1995 dollars. The projects are grouped into conveyance projects and treatment projects.

TABLE 8-1
Capital Cost Estimate (1995 dollars)

Description		Cost[a] ($ million)
Conveyance Projects		
Tributary SSO & Flooding Control CIPs		10.8
Remaining SSO & Flooding Control CIPs		10.5
New Interceptor to Willow Lake		24.7
	Subtotal	**46.0**
Treatment Projects		
Interim Solids & Dechlorination		2.0
Interim Outfall & Diffuser		0.7
Food Process Water - Phase I		8.0
Willow Lake Natural Treatment - Phase I		5.8
Food Processing Water - Phase II		7.3
Willow Lake Conventional Treatment		160
Willow Lake Natural Treatment - Phase II		15.5
	Subtotal	**199.3**
	Total	245.3

[a] ENR Construction Cost Index for the Northwest in October 1995 = 5,934