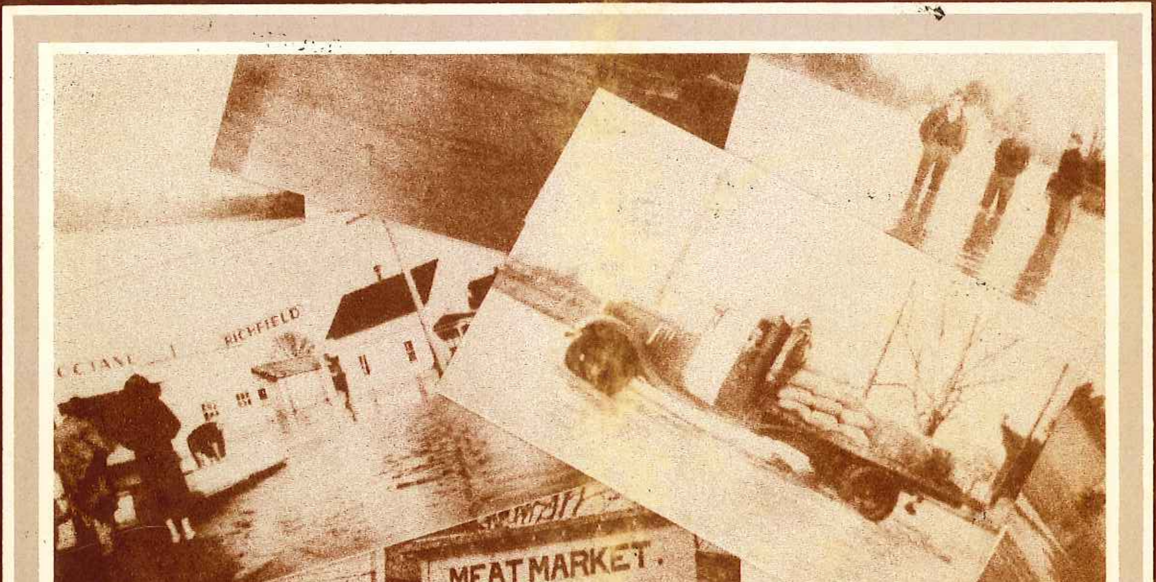
tualatin drainage plan



R.A.Wright engineering
consulting engineers

Honorable Mayor and City Council
City of Tualatin
Tualatin, Oregon

Gentlemen:

We have completed our study of storm drainage systems for the City of Tualatin and surrounding areas. The Tualatin Drainage Plan presented herein provides a review of existing drainage conditions, estimated future storm flows, recommended drainage improvements, estimated costs of improvements and policy and financial recommendations for implementing a storm drainage improvement program. Supplemental engineering computations and storm sewer profiles, not included in this report, have been submitted to the City Engineer.

A summary of this report and an outline summary of its recommendations are included in Chapter VII. The report concludes that the proposed improvements can be constructed from revenues generated by doubling the present building permit fee. In order to correct existing drainage problems, this report recommends that a $350,000 general obligation bond issue be approved for construction of drainage improvements. These bonds can be retired from projected building permit fee revenue. Property taxes or other levies will not be required.

We wish to express our appreciation to the Council of the City of Tualatin for retaining our firm to develop this plan and to the staff of the City of Tualatin for their assistance in the preparation of this plan.

Respectfully submitted,

Robert A. Wright

Robert A. Wright

1302 S.W. Bertha Boulevard Portland, Oregon 97219 503/246-4293

CITY OF TUALATIN
OREGON

TUALATIN DRAINAGE PLAN

CITY COUNCIL

James Brock, Mayor
Dan Conover
James Enger
Roma Garrett
Robert Herring
Bernice Ladd
Wallace Nelson

R.A. WRIGHT ENGINEERING
CONSULTING ENGINEERS
PORTLAND, OREGON
SEPTEMBER 1972

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INTRODUCTION

CHAPTER I
INTRODUCTION

PURPOSE

Presented in this report is a plan for routing surface drainage through the City of Tualatin and through its surrounding areas. The plan is a general or "master plan". Even though the need for a drainage plan was demonstrated by specific, existing drainage problems, the thrust of this plan is toward general area-wide drainage systems. The plan inevitably provides answers to specific problems, but this is more a supplemental benefit of planning than a specific goal.

To the land owner or developer the plan shows the existing or proposed drainage patterns that will serve and, possibly, cross his property. To the Council the plan will provide an overall view of the drainage system, its major problems and their solutions. The solutions include not only the facilities to be constructed but also proposed financial and administrative policies to implement construction.

Although the public and the Council will find this drainage plan useful, its greatest value will accrue to the City staff. With this report, and its supporting technical material, the City staff can readily evaluate individual drainage proposals and determine their compatibility with overall drainage needs. Even more important than its proposed physical drainage facilities the plan recommends a definable, equitable, and workable policy for allocating drainage responsibilities and costs between the City, the benefited properties, and other affected properties. This plan presents guidelines for a policy that, hopefully, will enable the City staff to act uniformly and effectively upon matters of land drainage within the City of Tualatin.

LOCATION

The overall area of study for this drainage plan includes the existing City of Tualatin and all surrounding areas that are now, or may someday be, influenced by the City of Tualatin. The specific boundary that encloses this area is shown on Figure 1. The approximate limits that define the area are Cipole Road on the west, Stafford Road on the south, Wanker's Corner on the east, and the Sherwood Inn on the north.

Within the overall study area is a smaller area, also shown on Figure 1, that includes most of the presently incorporated land of Tualatin. The smaller area has been given more detailed consideration than the remainder of the study area. The larger study area is approximately 11,500 acres, including 4,000 acres in the smaller, primary study area. This smaller area has been designated Zone I and the remaining study area has been designated Zone II.

AUTHORIZATION

On March 12, 1972 the City Council of the City of Tualatin authorized the preparation of a master drainage plan and approved an agreement between the City and R. A. Wright Engineering for preparation of the plan.

SCOPE OF WORK

The general directive for this drainage plan stated that the work "shall include preparation of the master drainage plan report, investigation of existing field conditions and drainage facilities, review of present and past drainage practices of the City of Tualatin, and presentation of the final report to the City Council."

The specific work items in the engineering investigation and drainage report include:

1. Review existing drainage facilities.
2. Summarize previous studies and reports.
3. Determine principal drainage areas.
4. Determine areas of inundation.
5. Locate existing and potential drainage problem areas.
6. Review past drainage practices and policies within the City.
7. Recommend hydraulic and hydrologic data and values to be used for drainage planning in the City.
8. Summarize hydraulic and hydrologic computations.
9. Prepare plan and profiles of proposed drainage facilities in Zone I.
10. Recommend a plan for implementation including priorities.
11. Explain and recommend the available methods of financing.
12. Recommend phasing of facilities.
13. Recommend construction methods and materials.
14. Prepare cost estimates.
15. Recommend drainage policies.

16. Recommend a plan or procedure for management of the Tualatin River flood plain.

RESOURCES

Aerial Mapping Company of Oregon was retained by the City of Tualatin to prepare topographic maps of Zone I of the study area. These maps show 2 foot contours at a scale of 1 inch equals 100 feet and were prepared to facilitate the more detailed drainage planning required for Zone I.

Plans of the freeways through the study area were reviewed at the offices of the Oregon State Highway Department. The freeways through Tualatin, however, have been constructed in many phases over several years and existing plans do not adequately depict the present condition of many culverts. For this reason most of the information on freeway drainage facilities has been obtained from field reconnaissance.

Most of the storm drains in Tualatin, excepting the freeway drain systems, have been built in recent years to serve residential subdivisions. The City's subdivision plan files were used to determine the extent and adequacy of these existing storm drain systems.

Road culverts, which are the predominate drainage facility in the study area, were established entirely from field surveys. Although this is generally the most reliable means of establishing existing conditions, there were some cases where existing topography and flow patterns indicated the existence of a road culvert but none was found. Other culverts were so plugged with silt and overgrown with vegetation that they were found only after intense searches. The possibility therefore exists that some existing culverts are not depicted in this report.

PREVIOUS REPORTS AND STUDIES

The previous drainage reports and studies for Tualatin and adjacent communities that have some significance to this drainage plan are as follows:

1. *Storm Sewer and Drainage Study of the Lake Oswego Area.* Cornell, Howland, Hayes & Merryfield, 1968.

This report considers drainage needs of the Lake Oswego area extending west to the Clackamas County line and south to the Tualatin River in the Tualatin area. A small area of the Lake Oswego study overlaps the Tualatin study area.

The Lake Oswego study is a complete drainage plan for its area and had a scope very much like this plan. The chapter on Design Criteria contains a very thorough review of the relationship between rainfall intensity, duration, and frequency in the Portland area. The information from the Lake Oswego report is valid for a large area surrounding Lake Oswego and has subsequently been used for drainage plans in several other Portland metropolitan communities.

The financial section of the Lake Oswego report describes the storm drain financing policies of four other Oregon cities, but does not attempt to present a detailed financial plan or a recommended financing policy for the City of Lake Oswego. Illustrated financial programs are presented based upon property tax revenue and revenue from both water users and property taxes. Neither plan is advocated and the report assumes that a more complex program will someday be developed to finance the proposed improvements.

2. *Storm Drainage Report, West Linn, Oregon.* Cornell, Howland, Hayes & Merryfield, 1969.

This report covers the area between the Tualatin River east of the Stafford Road Bridge and the south limit of the Lake Oswego drainage report. The West Linn study area is adjacent to the Tualatin study area only at the east extreme of the Tualatin area.

The financial section of the West Linn study is the same as the Lake Oswego study in its discussion of policies in other cities and its disclaimer that the illustrated financial programs presented constitute a detailed financial analysis. The financial illustrations are for one program in which the city pays only the additional cost of installing sewers over 15 inches in diameter and another program in which the city pays all costs of sewers over 15 inches in diameter. For each of these programs three alternatives for financing the city's costs are illustrated. Two of the alternatives are based upon property taxes and one utilizes a surcharge on water bills.

3. *Southwest 80th Avenue Storm Sewers, City of Tualatin.* Cornell, Howland, Hayes & Merryfield, January, 1971.

This is a brief letter report concerning drainage problems associated with construction of the City Hall. The report presents a plan for collecting drainage from 80th Avenue and routing it north and east to the Tualatin River. Most of this proposed system has subsequently been constructed by the developer of the K-mart property.

4. *Galway Hill Drainage System, City of Tualatin.* Cornell, Howland, Hayes & Merryfield, August, 1971.

This is another brief letter report. It concerns the drainage problems of the Galway Hill subdivision. Most of this area is located below the lowest natural drainage outlet and is located between two drainage basins. With storm drains this area could be drained to either drainage basin. The report recommends that storm drains and ditches be constructed to drain the area south to Hedges Creek; however, the city and the subdivision developer are presently working to drain the area north into the Nyberg Creek basin.

ACKNOWLEDGEMENTS

We gratefully acknowledge Yvonne Addington, City Administrator, and DeMar Batchelor, City Attorney for their review of and contributions to the financial and city policy sections of this report; and David Bryan, Director of Public Works, for his contributions to all phases of this report.

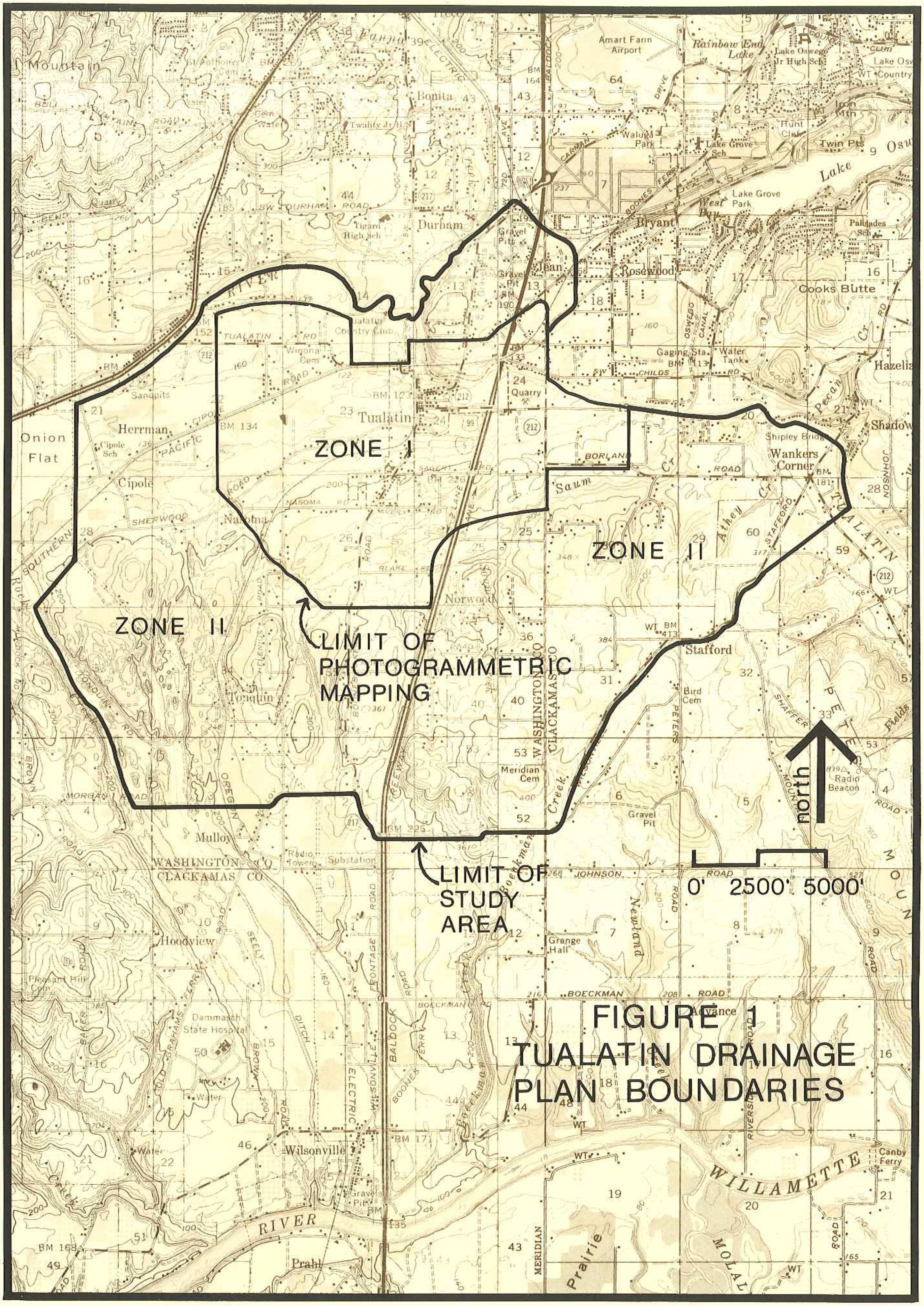


FIGURE 1
TUALATIN DRAINAGE PLAN BOUNDARIES

EXISTING DRAINAGE

CHAPTER II
EXISTING DRAINAGE

DRAINAGE BASINS

Drainage patterns within the study area are diverse, and surface runoff flows to ten principal drainage basins. Of these ten drainage basins, only Hedges Creek and Nyberg Creek are entirely within the study area; and Athey Creek and Saum Creek have only small areas that are outside the study area. The study area includes only minor portions of the remaining six drainage basins, all of which are large enough to extend far beyond the Tualatin study area.

These drainage basins and their approximate areas within this drainage plan are:

Athey Creek	550 Acres
Saum Creek	2,950 Acres
Nyberg Creek	1,000 Acres
Hedges Creek	2,500 Acres
Rock Creek	800 Acres
Fanno Creek	300 Acres
Lake Oswego	100 Acres
Tualatin River	900 Acres
Boeckman Creek	500 Acres
Seelye Ditch	1,900 Acres

Boeckman Creek and Seelye Ditch flow south to the Willamette River. The other basins flow to the Tualatin River.

The limits of these major drainage basins and their sub-basins within the drainage plan are shown on Plates 1 thru 9 at the end of this report.

EXISTING DRAINAGE SYSTEMS

Open ditches or creeks, combined with culverts at road crossings, constitute the predominate existing drainage system in Tualatin. The two interstate highways are served by an extensive system of cross drains and culverts. The only other drainage structures that have any significant value or future utility are the storm drains of the recent residential subdivisions. Since culverts are usually easy to replace, they normally are not significant to a long range drainage plan.

The Zone I study area contains all of the Nyberg Creek basin and most of the Hedges Creek basin. These two creeks flow past the core area of Tualatin and, other than the Tualatin River, they are presently the most important drainageways in the Tualatin area.

Hedges Creek flows in a well defined channel between Tualatin Road and the Tualatin River. East of Tualatin Road, however, it flows for about two miles through flat low agricultural land. In most of this area, the Hedges Creek channel is shallow or non-existent. Near the west limit of Zone I, Hedges Creek becomes a swamp with no definable channel.

One fork of Hedges Creek originates at a shallow lake, or swamp, in the Tonquin area. This area is shown on Plates 2 and 3 at the end of this report. From the lake to Sherwood Road, it flows in a moderately deep creek bed. North of Sherwood Road it enters the low area described above.

Tonquin Lake is a backwater of Hedges Creek that apparently was formed when the railroad was constructed through the area. Two railroad trestles were constructed across the creek allowing the creek to meander from one side of the railroad to the other. At the last downstream crossing of the creek, however, no trestle was constructed, and the railroad embankment serves as a dam forming Tonquin Lake. A small amount of water, maybe 50 gallons per minute, can flow through the embankment at the downstream crossing. Whether there is a small or partially plugged culvert under the embankment, or whether the embankment is porous at this point could not be determined. Regardless of the cause of the flow through the embankment, the net effect of the restricted flow and the large backwater is a well regulated discharge into Hedges Creek. About 150 acres drain into Tonquin Lake. If, in the future, the flow restriction is removed and the lake is drained, the downstream drainageway will have much higher maximum flows.

About one-half mile below Tonquin Lake, Hedges Creek flows through a recently installed 24-inch corrugated metal culvert, as shown on Plate 2. About 200 acres are drained through the culvert. Since the aerial photo for Plate 2 was made, a large metal building has been constructed on an embankment over the 24-inch culvert. A brief discussion with the building contractor indicated that he grossly underestimated the land area that would drain through the culvert. Subsequent analysis of the potential storm runoff through the culvert indicates that without the regulating effect of Tonquin Lake, the 24-inch culvert is only sufficient for a storm of 5-year frequency. As long as the railroad embankment serves as a restriction to storm runoff from Tonquin Lake, the new industrial building is in little danger. If this railroad restriction is ever removed, however, the building would be very vulnerable to flood damage and possibly total destruction.

The new industrial building is part of an industrial complex located at the confluence of the two forks of Hedges Creek. At this point the Tonquin fork joins a large fork from the east that drains about 400 acres of agricultural land. About 100 yards below this confluence the industrial developer has constructed a 20-foot high earth dam. The dam forms a small reservoir extending a short distance up both forks of Hedges Creek, as shown on Plate 2. The operating outlet of the dam is a 48-inch CMP standpipe that discharges to the creek at the downstream toe of the dam. Near the east end of the dam there is a 48-inch CMP culvert that serves as a high water, or emergency outlet.

A detailed analysis of the dam and its appurtenances is beyond the scope of this report. However, a cursory analysis of the dam indicates that with the present rural land use and upstream flow restrictions, the present outlet pipes are adequate. With future development and upstream drainage improvements, this condition will reverse. The 48-inch emergency outlet has no downstream spillway or erosion control, and while the outlet may someday pass all of the water necessary, there is a good chance that a major portion of the dam will be washed out in the process.

At present Hedges Creek is a series of backwaters, dams and swamps that serve to regulate the rather modest runoff from the rural land in the basin. Because a substantial portion of the lower basin is presently zoned for industrial use and is selling for five to fifteen thousand dollars per acre, the land is certain to be developed soon. When the land is developed it will no longer serve to regulate flow, but instead will contribute substantial storm runoffs.

Nyberg Creek flows through a flood plain between Boones Ferry Road and the Tualatin River, as shown on Plate 5. Above Boones Ferry Road, Nyberg Creek is fed by a ditch along the south side of the Oregon Electric railroad tracks and by a ditch on the east side of Boones Ferry Road. Much of the present flow to Nyberg Creek at one time flowed to Hedges Creek; however, when the Oregon Electric railroad tracks were constructed some drainage routes were blocked and flow was diverted to Nyberg Creek. The present drainage pattern is satisfactory and has been in effect long enough that there is now no reason to redivert the flow.

A substantial part of the recent residential development in Tualatin has occurred in the Nyberg Creek drainage basin. With this development a number of drainage problems have been created. Some of these are discussed later in this chapter.

Saum Creek drains a large agricultural and low density residential area east of the City of Tualatin. Most of this basin is in Zone II, the undeveloped portion of the study area, but development and its resultant drainage problems are expected in the foreseeable future.

Saum Creek and its tributaries are a valuable natural asset to the area. There are several small dams across the creek, and residents use the reservoirs for fishing and swimming. High value homes have been constructed along Saum Creek and its tributaries. Many are extensively landscaped.

The new I-205 freeway crosses the Saum Creek basin and has many drain culverts. The predominate culvert is 18-inch CMP, even though the areas that are served vary substantially. The result is most culverts are adequate or oversized and a few are undersized. None of the apparently undersized freeway culverts are located where they should cause concern to adjacent private property owners.

The route of Saum Creek is very scenic and generally undeveloped. The Tualatin Plan shows the land along Saum Creek and its tributaries to be "general open space". To the extent that this plan can be implemented, it will also alleviate future drainage problems. For both aesthetic and flood control purposes, it is important that future embankments and other structures over Saum Creek be controlled.

Existing drainage systems are shown on Plates 1 through 9 at the end of this report.

FLOOD PLAIN

The existing core area of the City of Tualatin is highly vulnerable to flooding of the Tualatin River. According to *Flood Plain Information, Tualatin River and Tributaries,* prepared by the U.S. Army Corps of Engineers in June, 1969, a flood of probable 10-year frequency will have a maximum water surface of elevation 120.4 feet (U.S.G.S. Datum) at the Boones Ferry Road bridge. For the 20- and 100-year frequency floods these maximum water surface elevations would be 121.6 feet and 124.5 feet, respectively. The areas that will be inundated by these floods are shown on Plates 1, 4, 5 and 8.

The highest recorded flood on the Tualatin occurred in December 1933 with a maximum water surface elevation of 122.4 feet at the Boones Ferry Road bridge. Although there are inadequate records, high water marks indicate that a flood in 1890 equaled or exceeded the 1933 flood. Other lesser floods occured in February 1949, December 1955, and December 1964.

The Corps of Engineers designates a 100-year flood as an Intermediate Regional Flood. Although this frequency of occurrence would indicate a rare flood and, for Tualatin, the effects of such a flood would be catastrophic, the Corps describes an even more severe flood which they call a Standard Project Flood. This is the flood that may be expected from the most severe combination of meterological and hydrological conditions that are considered reasonably characteristic of the geographical area, excluding extremely rare combinations. Such a flood would probably have peak flows 40 to 60 percent higher than the 100-year frequency flood.

A water surface elevation of 124.5 feet for a 100-year flood does not mean much to the average Tualatin resident. He can, however, understand that probably once every 100 years flood waters will be 5.5 feet deep in the Tualatin Post Office and 2.5 feet deep in the City Council chambers. During the next 20 years there is an even chance that flood waters will at sometime be 2.5 feet deep in the Tualatin Post Office.

Nyberg Creek is subject to backwater from the Tualatin River every year. This is frequent enough that the flood threat is obvious to any potential developer. The creek and its surrounding area will, therefore, likely remain in its present natural condition until land values rise to the level where deep land fills are feasible.

The road surface of Merdian Road across Nyberg Creek is about elevation 117.5. At this elevation the bridge and adjacent road surface are subject to flood waters every 10 years. In the past such high water has resulted in minor inconvenience to travelers and little or no damage to the bridge and roadway. Flood damage will probably remain minor, but with the construction of the new Meridian Park Hospital, traveler inconvenience takes on potentially serious consequences. The Meridian Road crossing of Nyberg Creek is on the primary route between the I-5 freeway and the hospital. During flood periods traffic to the hospital will have to be detoured to Boones Ferry Road and approach the hospital from Sagert Road. As a minimum precaution against closure of the Meridian Road Bridge, the hospital, or the city, should have clearly marked hospital detour signs available. A study should also be made of the feasibility of raising the Meridian Road Bridge and road embankment.

Flood control and flood plain management is only a minor topic of this report and drainage plan, however, to some sections of Tualatin, the core area specifically, the flood danger is so acute that other analyses and recommendations presented in this report must take secondary importance to flood plain control. It is commonly believed, and in fact was stated in one of Tualatin's earlier drainage studies, that future flood control projects on the Tualatin and Willamette Rivers will appreciably affect flood conditions at Tualatin. This is not true. The Tualatin River drops about 50 feet between Tualatin and the Willamette River and under no combination of conditions could the Willamette River affect flood conditions at Tualatin. Proposed dams in the Tualatin River basin on McKay Creek, Rock Creek, and Scoggins Creek will provide only minor flood control benefits to the Tualatin Valley and as far down river as Tualatin the affects will be insignificant. The benefits of proposed storage projects will probably be more than overcome by increased runoff from future urbanization of the Tualatin Valley.

Proposed flood plain management policies are included in Chapter V of this report.

SPECIAL PROBLEM AREAS

Boones Ferry Road. The Navajo Hills subdivision was partially developed on land that was lower than the lowest natural outlet, geologically referred to as a "sink". This sink was located along the divide between the Saum Creek and Nyberg Creek drainage basins. The lowest natural outlet for the sink would have discharged storm water to the east, across Interstate 5, and then into Nyberg Creek. In order to get sanitary sewer service by gravity flow, the sink had to be extensively regraded. Either for revising the drainage or improving the lot contours, almost every lot in the subdivision was regraded.

A storm drain system was installed in Navajo Hills. The sink area was combined with a small area in the Nyberg basin and storm flow from the two areas was piped to the ditch on the east side of Boones Ferry Road. The east half of Navajo Hills was connected to the existing storm drains in Sandalwood Park and has presented only minor problems. The storm sewer that discharges to the Boones Ferry roadside ditch; however, has presented serious problems.

There have been many complaints from property owners along Boones Ferry Road that the additional storm discharge is carrying sand that fills the ditches. These same complaints are coming from property owners as far down as Nyberg Creek. This silt and sand does come from Navajo Hills and results from the uncovered excavation material eroding during the winter rains. Such erosion will decrease as the area develops and should stop at full development. In the interim the developer can, and should be required to, route the runoff through the site such that erosion is minimized. When extensive site regrading is proposed it should be accompanied by a plan to control erosion and prevent any off-site discharge of soil particles.

Of longer lasting concern than any initial erosion problems are the consequences of discharging large amounts of storm water into a roadside ditch. The existing culverts along Boones Ferry Road plugged several times last winter and caused some minor property damage. Present plans call for eliminating, or reducing this problem by installing new, larger culverts. Even if the new culverts are capable of carrying the maximum ditch flow, the 24-inch storm drain from Navajo Hills can discharge 13 cubic feet per second (cfs) into the ditch. This is more than the ditch can safely carry. The Boones Ferry Road ditch is steep and the storm water will flow very fast carrying the potential for destruction if it is restricted or diverted. Existing ditch banks will erode from the high velocity flow. In the upper reaches the ditch will have to be deepened in order to accommodate new culverts, and since the ditch is very close to the traveled roadway, a deeper ditch will create an increased traffic hazard. The downstream end of the ditch is already so deep that it creates a danger to pedestrians and motorists.

The discharge of storm flow from Navajo Hills into the Boones Ferry ditch creates a public nuisance that will develop into a public danger. The installation of new driveway culverts will alleviate one symptom of the problem, but the continued development of Navajo Hills will accentuate the overriding danger of exposing the public to large quantities of storm runoff.

Galway Hills. Galway Hills, like part of Navajo Hills, was built in a sink. When the land was undeveloped all precipitation that fell in the sink percolated into the ground. Accounts vary on the extent to which this area experienced surface ponding before development. It appears, however, the percolation prior to development was at least sufficient to obscure the lack of an overland drainage outlet.

When the Galway Hills subdivision was constructed, street drainage was collected in storm drains and discharged near the north boundary of the property. Two problems were created by this. The subdivision was constructed across a swale, and by not extending the storm drain system to the south limit of the development, drainage from a small area to the south was blocked. The only way surface drainage from this area can reach the drain system is for it to flow across one of the platted lots in Galway Hills.

On the north side of Galway Hills the problem is even more serious. The drains that serve the subdivision discharge onto land with no drainage outlet. Storm water from Galway Hills percolates into the ground north of the subdivision, but the storm water often percolates slower than it is received. During the winter the inadequate rate of storm water percolation results in extensive ponding. The level of the surface water varies with precipitation.

The extent to which surface ponding after construction of Galway Hills exceeds previous ponding levels is now impossible to establish. Although some Tualatin residents claim the site has always been subject to wet weather ponding, it is reasonable to assume that the construction of Galway Hills has increased storm flows, decreased percolation areas, and generally aggravated the problem.

The quality of storm water has also changed with the development of the land. Where the storm water used to slowly flow through grasses and other vegetation, it now rapidly washes off of streets and driveways carrying gravel, silts, and many fine particles that are carried into the area by automobiles. When this storm water discharges onto the percolation area the foreign materials enter the soil and inhibit percolation. The rate at which drainage areas are plugged varies with the gradation of the native soil and the amount of foreign matter that is discharged, but for moderately fine soils, such as in the Galway Hills area, decreasing percolation rates are inevitable.

During winter storms in 1972 the water surface in the percolation area was just inches below the road surface of Kilarney Lane for extended periods of time. On occasion the water rose above the road surface flooding the street and surrounding properties. During winters of low precipitation, the ponding will be reduced, but the continued deteriation of the percolation area, combined with the possibility of very high storm flows, makes this a condition that should be corrected as soon as possible.

Farm House Apartments. These apartments

were recently constructed on the south bank of the Tualatin River just east of the Boones Ferry Road bridge. They are a drainage concern for two reasons. First, they were constructed at an elevation that makes the first floor units vulnerable to flooding by the Tualatin River during a flood of only 10-year frequency. And second, the project filled a drainageway that had previously drained the adjacent land owned by the Tualatin Rural Fire Protection District.

The flooding problem is without apparent solution. The drainage of the Fire District property may be possible with a connection to the new storm sewer through the K-mart property. If this is not possible, the Fire District may have to exercise its right to the former drainage way.

Itel Property. Mr. Itel owns property north of the intersection of 93rd Street and Sagert Road. A natural drainageway crosses the property, and in order to facilitate the cultivation of the property, Mr. Itel many years ago installed drain tile to route the storm drainage beneath his field. As the land above Mr. Itel's property changed from agricultural to residential use, the storm flows increased. In recent years, the drain tile has been unable to carry some heavy winter storm flows and the storm waters have spilled out of the headworks to the drain tile and flowed overland across Mr. Itel's field. Mr. Itel feels that the City of Tualatin is responsible for the storm drainage and has threatened legal action against the City.

Existing plans for additional upstream developments will make this problem more acute.

DESIGN CRITERIA

CHAPTER III
DESIGN CRITERIA

LAND USE

The rate of storm runoff from land is heavily influenced by the level of development of the land. As an example, storm runoff from agricultural land, particularly a recently plowed field, would be only 10 to 20 percent of the flow that would result if that same land were covered with buildings and paved parking lots. While a drainage plan must consider present land use, its major emphasis must be toward future land use and future storm flows.

The Tualatin Plan, prepared by the Tualatin Citizens Advisory Planning Commission, with the assistance of Cornell, Howland, Hayes and Merryfield, was used to establish future land use patterns for this drainage plan. The land that is planned for use as open space, agriculture, and low density residences will only slightly increase present storm runoff. The industrial and commercial areas, however, will experience substantially increased storm flows when they develop as shown on the Tualatin Plan. This is particularly significant in the lower Hedges Creek basin where existing swamp land, with negligible storm runoff, is planned for industrial use with high storm runoff. The projected change of the existing core area from predominately vacant or partially developed land to dense commercial buildings and parking lots will significantly increase storm runoff in this area also. A reprint of the Tualatin Plan is included in the Appendix.

RUNOFF COEFFICIENTS

The formula used in this drainage plan to estimate storm runoff is based, along with other factors, upon the extent to which the land and surface improvements encourage or retard the overland flow of precipitation. This characteristic of the land use is indicated by a runoff coefficient that can vary from 0 to 1.00, with typical values ranging from 0.10 to 0.90. A smooth dense material, such as a pane of glass would have a runoff coefficient of 1.00, meaning that all of the precipitation that lands on the material will run off of it. A very porous material, such as dry sand, would be at the other extreme and would have no surface runoff, as indicated by a runoff coefficient of zero.

Since the runoff coefficient that is used is based upon predicted average land development at some future time, it is less than a precise value and subject to some allowance for judgment. Actually, there are more parameters than simply land use that could be included in the selection of a runoff coefficient. Runoff will vary with the slope of the land, with the saturation of the soil, with the duration of the storm, with the proximity of minor drainageways, and with other lesser factors. Generally, refinement of the runoff coefficient to reflect these other parameters is unjustified when compared to the inherent lack of precision in the selection of other factors in the formula and the wide range of generally accepted runoff coefficients.

The runoff coefficients used in this plan and recommended for future storm flow analyses in the Tualatin area are shown in Table 1.

RAINFALL

Everyone associates heavy surface runoff with severe rain storms. While this is a true relationship, rainfall must be further evaluated according to intensity, duration, and frequency in order to utilize the relationship between rainfall and runoff in estimating storm flows.

Intensity indicates the amount of rain that falls on an area in a given amount of time, and is usually measured in inches per hour. Duration is the time period over which the rainfall was measured. In small drainage basins, such as in the Tualatin area, rainfall duration is normally expressed in minutes. In large basins duration is normally expressed in hours.

There is an inverse relationship between rainfall intensity and duration. Very heavy rains, or high intensity rains, will normally be of very short duration. As the rains continue for long periods of time the average intensity decreases. By measuring both the intensity and the duration of storms in a region, the U.S. Weather Bureau has been able to develop statistical data that provides the highest probable intensity for storms of a given duration and a given probable frequency of recurrence.

The frequency of a given storm reflects the period of time, normally years, in which the storm will probably occur once. The more severe the storm, the less frequent it is likely to recur. Frequency of recurrence is an important factor in determining what level of storm a drainage system should be capable of accommodating.

In establishing the storm frequency for which a drainage facility will be designed, the conse-

TABLE 1
RUNOFF COEFFICIENTS

Land Use	Land Slope		
	2% or less	2% – 7%	7% plus
Agriculture Low Density Residential	.15	.20	.25
Low Density Residential	.40	.45	.50
Medium Density Residential	.50	.50	.55
High Density Residential	.70	.70	.70
Commercial	.90	.90	.90
Light Industrial	.65	.65	.65
Heavy Industrial	.75	.75	.75
Parks and Open Spaces	.10	.15	.20

quences of system failure should be evaluated. If system failures result only in public inconvenience, for example, they may be tolerated more frequently than failures that result in property damage or personal injury. Public inconvenience can further by evaluated according to the number of people inconvenienced and the duration. Property damage analyses must, of course, reflect the extent of probable damage.

Recommended storm frequency limits for various conditions are shown in Table 2.

The Lake Oswego drainage report by CH2M contains a very thorough review of storm data for the Portland Metropolitan area and presents a compilation of available rainfall intensity, duration and frequency data in both tabular and graphic form. For storms of 5-year frequency, the Lake Oswego data shows slightly lower intensities than the U.S. Weather Bureau for storms of 10-and 20-minute duration. For storms of longer duration, however, the Lake Oswego data shows slightly higher intensities than the U.S. Weather Bureau. Since the time that the Lake Oswego report was printed, the U.S. Weather Bureau has published new rainfall intensity maps for Oregon; however, the new maps only show intensities for storm durations of 6 hours and 24 hours, both of which are too long to have any significance in Tualatin.

The Tualatin drainage plan, like most recent drainage plans in the metropolitan area, utilizes the storm intensity, duration, and frequency

TABLE 2
DRAINAGE SYSTEM STORM FREQUENCY DESIGN CRITERIA

Probable Results of System Failure	Area Development		
	Sparse	Moderate	Dense
Public Inconvenience	1- 3 yr	2- 5 yr	5- 10 yr
Property Damage	3-10 yr	5- 15 yr	10- 25 yr
Personal Injuries	25-50 yr	25-100 yr	25-100 yr

data originally presented in the Storm Sewer and Drainage Study of the Lake Oswego Area, by Cornell, Howland, Hayes and Merryfield. The information is shown in this report in Table 3.

STORM FLOW ANALYSIS

Storm flow in the Tualatin drainage plan has been estimated using the "rational formula" of computing storm runoff. This formula states that the storm runoff (Q), in cubic feet per second (cfs), is equal to the product of the area (A), in acres; the runoff coefficient (C); and the rainfall intensity (I), in inches per hour. Abbreviated, this formula is Q = CIA.

Since the rational formula is a simple summary of many complex and constantly changing factors, it must be applied with judgment. The formula is generally considered to be inadequate for drainage basins larger than 5 square miles. The Saum Creek basin is the largest in the Tualatin area and contains 2,950 acres, or 4.6 square miles.

STORM DRAINS

The following are both design criteria and recommended construction standards for storm drains.

Material. Concrete, clay, and asbestos–cement (A.C.) pipe are all suitable materials for the construction of storm drains. Of these materials, concrete is the only one that is locally produced. The price of concrete pipe is normally less than the price of clay or A.C. pipe, particularly in the larger sizes. All of the proposed storm drains shown on Plates 1 through 9 have been sized based upon the flow characteristics of circular concrete pipe. This pipe was chosen becuase it is the most common type of storm drain in the Northwest. When the proposed storm drains are constructed, the designer may choose another material or he may choose an oval or other shape of conduit. Other shapes or even multibarrel drains may be necessary in order to avoid existing underground utilities.

Corrugated Metal Pipe (CMP) is used for culverts and storm sewers, particularly culverts. It has been used extensively on the freeways in the Tualatin area. Corrugated metal pipe, however, cannot be considered equal to concrete pipe. The corrugations in CMP provide flow characteristics inferior to the smooth walls of most other pipes, and since CMP is basically steel, it is subject to corrosion. Pipe corrosion can be reduced by galvanizing the pipe or coating it with coal tar or asbestos. Flow characteristics can also be improved by a heavy interior coating that smooths out the corrugations. Offsetting the disadvantages of CMP is the price, which is usually lower than for concrete pipe.

For any given installation either CMP or concrete pipe may be more appropriate depending upon the required service life and expected flows. CMP usually has a lower price and a shorter service life than concrete pipe. Pipe cost versus service life must be evaluated for each individual storm drain installation.

Aluminum, fiberglass and plastics are all pipe materials that may someday be used as storm drain materials, but as yet they are not com-

TABLE 3
RAINFALL INTENSITY, DURATION, AND FREQUENCY

INTENSITY, INCHES/HOUR

Duration Minutes	Frequency 2 Yr.	5 Yr.	10 Yr.	25 Yr.	50 Yr.	100 Yr.
5	1.92	2.50	3.20	3.88	4.53	4.95
10	1.38	1.79	2.30	2.79	3.26	3.56
15	1.11	1.45	1.86	2.24	2.62	2.86
20	.95	1.23	1.58	1.92	2.24	2.45
30	.75	.97	1.25	1.51	1.77	1.94
40	.62	.80	1.03	1.25	1.46	1.60
50	.54	.70	.90	1.09	1.28	1.39
60	.49	.64	.82	.99	1.16	1.26
90	.40	.51	.65	.81	.95	1.03
120	.34	.44	.55	.68	.79	.85
150	.30	.39	.50	.62	.71	.77
180	.27	.35	.45	.55	.64	.70

petitive enough to warrant consideration.

Capacity Analysis. The capacities of existting and proposed storm sewers were computed using the Manning equation with a roughness coefficient (n) of 0.013 for concrete, clay, and asbestos cement pipe and 0.024 for CMP.

Velocity. In order to move suspended particles through sewers and prevent sedimentation, storm drains should be constructed on slopes that will produce a minimum velocity of 3 feet per second.

Change in Pipe Size. Where the downstream pipe is larger than the upstream pipe the 0.8 diameter depth of the upstream pipe should be at or above the 0.8 diameter depth of the downstream pipe. When the downstream pipe is smaller, the inverts should be matched.

Location. Since water flows downhill, storm drains can be of most service when they are located lower than the surrounding land. Sometimes storm drains can be located on public rights-of-way and still provide satisfactory service, but frequently the low lands that must be drained or at least crossed by the storm drain are privately owned. This requires that the land owner grant an easement for the drain and that the drain be constructed across private property. When an easement is necessary every attempt should be made to locate the drain along a property line, through less developed areas, and through the area that best suits the landowner.

On public roadways the storm drain can most economically be constructed along the unpaved road shoulder or ditch line; however, most communities have water service, gas service, telephone service, and sometimes sanitary sewers before they construct storm drains, and the economical locations are already taken. This usually requires that the storm drain be constructed within the paved roadway. If storm drains are located in one traffic lane rather than the road center line, traffic flow during construction is usually improved.

Depth. Storm drains should be constructed with a minimum of 30-inches of cover over the top of the pipe, but, more important, sewers must be constructed deep enough to intercept runoff from the areas that they are intended to serve. On a street this means that the storm drain must be deep enough to allow street runoff to flow into a catch basin through the connecting pipe and into the storm drain. Care must be taken to assure that the connecting pipe has sufficient cover and sufficient drop to avoid other utility pipes that may have to be crossed.

On private property storm drains must be deep enough to allow for any foreseeable site grading.

Manholes. Manholes should be located at all drain pipe intersections, changes in drain slope, and changes in drain size. It is desirable, but not mandatory that catch basins connect to the storm drains at manholes. When manholes are not available to intercept catch basin flow, tee fittings will suffice.

Along curved rights-of-way it is sometimes desirable to construct curved storm drains. When this is necessary the storm drain curve must be no sharper than the minimum radius recommended by the pipe manufacturer, and the curve must be uniform between manholes.

Catch Basins. Since catch basins are usually the first point of contact between the storm water and the system, they are an important component of the system. If runoff can't enter the catch basins, the storm drains are of little value.

The proper design of catch basins is complex and cannot be satisfactorily reduced to a few design standards. In this case "design" refers more to the catch basin location, spacing from other basins, and its relation to the surrounding terrain, than to the physical characteristics of the catch basin. The Oregon State Highway Department has standards for catch basins. Since the OSHD catch basins function satisfactorily and have been widely accepted throughout Oregon it is a recommendation of this report that the City of Tualatin also accept the O.S.H.D. catch basins as its standard.

Drainage of Highway Pavements, Hydraulic Engineering Circular No. 12 of the Federal Highway Administration, U.S. Department of Transportation should be used as a guide for determining catch basin size and spacing. This circular describes methods of determining street gutter capacities and catch basin inlet capacities.

OPEN CHANNELS

Open channels include a wide range of ditches, creeks, streams, and rivers. Open channels are the predominate feature of Tualatin's present drainage system, and they will continue to play the major role.

The continued use of some existing drainage channels will require that they be improved. Usually this will mean some regrading and minor realignment. For the proposed channels on the lower ends of Hedges and Nyberg Creeks, channel construction will require some major excavation and embankment construction.

Channels, like storm drains, should be constructed on slopes that will produce a minimum velocity of 3 feet per second (fps). High velocities, however, cannot be tolerated in open channels to the same degree as for storm drains. Unprotected earth will erode at moderately low velocities, usually in the range of 5 or 6 fps. Channels that are designed for velocities above 5 fps should be lined with sod, gravel, or riprap.

Channel side slopes can vary according to the bank material. A side slope of 2 horizontal to 1 vertical is acceptable for most lined and unlined channels. Channels in park-like settings where the banks may be mowed should have side slopes of 3 to 1 or flatter. Riprap or concrete lined channels may have side slopes steeper than 2 to 1.

Open channels are recommended in the Tualatin drainage plan in all drainageways where the predicted storm runoff cannot be transported in a 72-inch storm drain or smaller. There are some areas, where storm drains are advocated in this plan, that will be served by open channels for many more years. Storm drains are much more expensive to construct than open channels and, for large storm flows, can only be justified in areas of high land value. Open channels will continue to serve as interim drainageways until the cost of closed conduits can be justified.

In many cases the additional cost of storm drains over open channels is entirely justified. Besides taking a larger land area than closed conduits, drainage ditches require more maintenance and frequently constitute a public nuisance or even danger. Most of these problems come from roadside ditches rather than drainageways across open land.

There is an obvious economic advantage for the land developer who can discharge storm water from his development into a roadside ditch. Several current problem areas clearly indicate that roadside ditches are unsatisfactory for large flows. In this drainage plan storm drains have been proposed along all roadways that will eventually intercept 10 cfs or more. For a roadside ditch to carry more than 10 cfs it must be either so deep or so wide that it would constitute a danger to motorists and pedestrians and would be a general nuisance.

CULVERTS

Culverts and storm drains are frequently lumped together in discussions of drainage facilities. They are not, however, the same thing. Culverts are usually rather short conduits under roadways and are distinguished from storm drains by being single conduits that receive storm water from an open channel and discharge to an open channel. Since culverts usually discharge into open channels, such as roadside ditches, they are usually constructed close to the ground surface.

The maximum level of water upstream is an important design consideration and one that must be evaluated individually for each installation. Most culverts can have 1.5 to 2.0 feet of backwater without causing damage to upstream property, but this is not always the case. For some culverts only half of their full capacity can be utilized because the water level for full submergance would cause upstream property damage or public inconvenience.

Since culverts are constructed close to the surface and may be temporary installations until storm drains are installed, the use of corrugated metal pipe with its lower cost and shorter life may be preferable to concrete or other pipe materials.

Culverts need more maintenance than storm drains but normally receive very little. This is true in Tualatin as well as most other communities in Oregon. Culverts are very susceptible to plugging by ditch silt, road gravel, vegetation, and litter. Plugged or partially plugged culverts are so prevalent, in fact, that rational analysis of culvert capacities is often unjustified.

PROPOSED IMPROVEMENTS

CHAPTER IV
PROPOSED IMPROVEMENTS

MASTER PLAN

Although this report takes credit for developing a master drainage plan for the Tualatin area, the basic elements of the plan have existed for several hundred and probably thousands of years. Since the drainage patterns in Tualatin were established by natural typography, they must remain essentially as they presently exist, and this report serves more to evaluate the effect of future development upon drainageways than to plan the storm drainage routes. There are, of course, exceptions to this. There are existing conditions where the railroad and land developers have altered natural flow patterns.

The drainage plan presented in this report attempts to channel drainage along present routes and presents no recommendations for grandiose diversion projects. Avoiding diversions is economically sound, and usually minimizes legal problems.

The drainage improvements proposed to meet Tualatin's existing and foreseeable future needs are shown on Plates 1 through 9 at the end of this report. For Zone I, drainage systems consisting of both open channels and storm drains are shown. Zone II does not presently have sufficient development to justify drainage system improvements, nor does it have sufficient growth patterns to predict future storm drain routes. Therefore, only various computed storm flows for the ultimate development are shown within Zone II and not pipe sizes and locations. Caution should be used in applying the computed flows, however, because any given structure could become obsolete before the assumed land use is realized.

PHASED IMPROVEMENT PROGRAM

The improvements proposed in this drainage plan not only <u>can</u> be part of a phased program, the magnitude of this total plan dictates that implementation of the improvement program <u>must</u> be phased. Since the need for many of the improvements is dependent upon future growth, the sequence of the phased improvement program cannot, and need not, be entirely established at this time. An effective phased improvement program must be flexible enough to meet or precede drainage problems, and it must have resources available to construct improvements with sufficient capacity to serve long range drainage needs. Improvement priorities to meet existing or immediately foreseeable drainage problems are recommended in the next chapter.

PROJECT COSTS

CHAPTER V
PROJECT COSTS

COST PREDICTIONS

The cost estimates presented in this report attempt to predict the costs of constructing the proposed improvements during the summer of 1973. This reference period was chosen because it is the earliest possible time that any of the proposed improvements could be constructed. Since most, if not all, of the proposed improvements will be constructed after 1973, most of the cost estimates presented in this report will have to be updated in order to be of use. The Engineering News Record construction cost index can be used to update the cost estimates in this report. As presented, the cost estimates are based upon a predicted ENR national construction cost index of 1800 in the summer of 1973. Costs for other periods can be approximated by multiplying the estimates in this report by the ratio of the ENR index for the time in question to the ENR index of 1800.

OPEN CHANNELS

Unit construction costs of open channel were developed for various widths and depths of channels. All side slopes were assumed to be 2 horizontal to 1 vertical. The unit excavation cost was determined by the following:

Excavation Cost

$$(\text{\$ per cubic yard}) = \$1.00 + \frac{\$1.00}{\text{number of cubic yards per linear foot}}$$

The following are examples of this. For a rather large ditch with 5 cubic yards per linear foot excavation would cost $1.20 per cubic yard. For a small ditch with only one c.y./lin. ft., excavation would cost $2.00 per cubic yard. The open channel unit construction costs are shown in Table 4.

STORM DRAINS

The cost of storm drain construction will be substantially greater if the drain must be constructed beneath pavement rather than beneath the road shoulder or undeveloped portion of the road right-of-way. The precise location, however, is dependent upon the location of other utilities and obstructions within the right-of-way and can only be established as part of the final design. The cost estimates are therefore based upon the conservative, and generally accurate, assumption that all storm drains along existing paved roadways will have to be constructed beneath the paved areas. This means that the additional costs of granular backfill material and trench paving material have been included in the cost estimates. For storm drains that are installed as part of street improvement projects, trench paving should be deducted from the cost estimates in this report.

In preparing the cost estimates for this report, the storm drain costs were divided into (1) trench excavation and backfill, (2) storm drain pipe, (3) manholes, and (4) surface restoration.

TABLE 4
OPEN CHANNEL CONSTRUCTION UNIT COSTS
($ Per Linear Foot)

Bottom Width ft.	Channel Depth 2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.
0	1.70	2.27	2.98	3.85	4.86		
2	1.94	2.59	3.38	4.32	5.41		
4		2.91	3.78	4.79	5.96	7.27	
5			3.97	5.03	6.23	7.63	9.06
6			4.17	5.26	6.50	7.89	9.41
7			4.37	5.50	6.77	8.19	9.76
8			4.67	5.73	7.04	8.50	10.00

Trench Excavation and Backfill. Trench excavation was assumed to be uniform throughout the area, and the possibility of encountering rock was considered to be sufficiently remote that no rock excavation allowance was included. Trench backfill was assumed to be either existing excavated material, conforming to APWA Class A, or imported granular material, conforming to APWA Class B. The imported granular material for Class B backfill was assumed to cost $3.50 per cubic yard, delivered to the project. The trench excavation and backfill unit costs are shown in Table 5.

TABLE 5
TRENCH EXCAVATION AND BACKFILL UNIT COSTS
($ Per Linear Foot)

Depth (feet)	Pipe Size (inches) 12 to 18	21 to 36	42 to 60	66 & 72
APWA Class A				
0-8	2.30	3.00	3.40	4.20
8-12	4.10	5.00	6.00	7.20
12-16	7.70	9.30	10.90	13.10
16-20	13.10	15.60	18.10	21.40
20-24	20.70	24.30	27.80	32.50
APWA Class B				
0-8	7.40	7.80	6.90	4.20
8-12	13.40	14.90	15.50	12.30
12-16	24.00	27.40	29.70	31.20
16-20	38.00	43.50	47.80	51.90
20-24	55.70	63.40	69.90	77.00

Pipe. Pipe prices include bedding gravel, gravel around the pipe, and pipe installation. Pipes 12 inches through 18 inches in diameter are assumed to be extra strength concrete. Sizes 21 inches through 72 inches in diameter are assumed to be Class III concrete. Table 6 shows the unit prices used for installed pipe.

TABLE 6
INSTALLED STORM DRAIN PIPE UNIT PRICES
($ Per Linear Foot)

Size	Price	Size	Price
12 inch	5.20	36 inch	23.50
15 inch	6.20	42 inch	30.40
18 inch	8.40	48 inch	36.90
21 inch	10.90	54 inch	42.50
24 inch	13.10	60 inch	50.20
27 inch	15.30	66 inch	56.50
30 inch	18.60	72 inch	67.30

Manholes. Manhole costs include the concrete base, precast sections, and manhole frame and cover. Manhole excavation and backfill is normally part of the pipe trench excavation and backfill and is not included in the manhole costs. Manhole unit costs are shown in Table 7.

TABLE 7
MANHOLE UNIT COSTS

	Pipe Size (inches)			
	12 to 21	24 to 36	42 to 54	60 to 72
Manhole 0 to 6 ft.	$380 ea.	$460 ea.	$770 ea.	$1040 ea.
Additional depth	$40 / ft.	$40 / ft.	$50 / ft.	$50 / ft.

Pavement. The pavement replacement costs are estimated to be $5.40 per square yard, which includes material and labor for a 2-inch layer of asphaltic concrete, and a 6-inch layer of crushed rock base. Table 8 shows unit costs for pavement replacement.

TABLE 8
PAVEMENT REPLACEMENT UNIT COSTS
($ Per Linear Foot)

Trench Depth (feet)	Pipe Size (inches)			
	12 to 21	24 to 36	42 to 54	60 to 72
0 to 8	3.90	4.80	5.70	6.90
8 to 12	4.80	5.70	6.60	7.80
12 to 16	6.00	6.90	7.80	9.00
16 to 20	7.20	8.10	9.00	10.20
20 to 24	8.40	9.30	10.20	11.40

Gravel Surfacing. Gravel surfacing costs are based upon an installed cost of $6.50 per cubic yard for an 8-inch layer of crushed rock. The unit costs for gravel surfacing are shown in Table 9.

TABLE 9
GRAVEL SURFACING UNIT COSTS
($ Per Linear Foot)

Trench Depth (feet)	Pipe Sizes (inches)			
	12 to 21	24 to 36	42 to 54	60 to 72
0 to 8	1.00	1.30	1.50	1.80
8 to 12	1.30	1.50	1.80	2.10
12 to 16	1.60	1.80	2.10	2.40
16 to 20	1.90	2.20	2.40	2.70
20 to 24	2.20	2.50	2.70	3.00

Culverts. By combining the unit costs for trench excavation and backfill, pipe, and paving, typical costs for culvert installation can be developed. The typical culvert costs presented in this report are based upon a 40-foot wide roadbed, with 24 feet of pavement, and 5 feet of graveled shoulder on each side. The embankment slopes are 1.5 to 1. As the road embankment deepens the length of culvert increases. The cost of the increased length of culvert is included in these cost estimates. Table 10 shows the typical culvert costs.

TABLE 10

TYPICAL CULVERT COSTS

Pipe Size (inches)	Embankment Depth (feet)				
	0 to 8	8 to 12	12 to 16	16 to 20	20 to 24
12	$ 800	$1,100	$1,700	$2,600	$3,900
15	800	1,200	1,800	2,700	4,000
18	1,000	1,300	2,000	2,900	4,200
21	1,200	1,600	2,200	3,500	5,000
24	1,300	1,800	2,600	3,700	5,200
27	1,400	1,900	2,800	3,900	5,400
30	1,600	2,100	3,000	4,200	5,800
36	1,900	2,500	3,400	4,700	6,300
42	2,300	3,000	4,100	5,600	7,500
48	2,700	3,500	4,700	6,200	8,200
54	3,100	3,900	5,100	6,700	8,800
60	3,600	4,400	5,800	7,500	9,600
66	3,900	4,800	6,400	8,400	10,800
72	4,600	5,500	7,300	9,400	11,900

Catch Basins. Since catch basins are normally constructed as part of a road improvement project, it is not always appropriate to include catch basin costs with storm drain costs. It is also difficult to be precise about catch basin costs because a major part of the cost is the connecting line between the catch basin and the storm drain. The length of connecting line will vary with the proximity of the catch basin to the storm sewer.

In this report all catch basins are estimated to cost $500 each. This includes the catch basin alone at $150, 25 feet of 12 inch pipe with granular backfill and trench repaving at $320, and a tee fitting on the storm drain at $30.

PROJECT COSTS

The preceding unit costs have been applied to the estimated quantities for most of the proposed drainage improvements shown on Plates 1 thru 9 at the end of this report. Estimated costs have been prepared for all improvements that have been given a designation (e.g. Main N, Lateral N6, Lateral H2-1, etc.). The costs of culverts that are not part of a designated system have been omitted. The approximate cost of road culverts can be obtained from Table 10.

All of the preceding discussions of estimated costs have concerned construction costs, or the estimated low bid that the City will receive from a general contractor for constructing the proposed improvement. The entire project, however, will include many other costs. These include legal, administrative, survey, engineering, inspection and right-of-way acquistiion costs. In addition, there should be an allowance for variations in contract quantities and for contract change orders. Frequently this is about five percent of the construction cost. Change orders during construction can result from unexpected subsurface obstacles or ground conditions, or they can result from an owner's desire to make minor design revisions during construction. To cover both the technical services and the construction contingencies, an allowance of 30 percent has been added to the estimated construction costs to give the estimated project costs.

Since almost all improvements are following existing drainageways and are improving the land that they cross, it has been assumed that any improvements that the City constructs across private property will be constructed upon easements granted by the landowner without payment from the City. The City would pay for all surveys, legal costs, and filing fees associated with the easement but would make no payment to the property owner solely as consideration for the easement.

The construction costs and total project costs for the recommended drainage improvements are shown in Table 11.

TABLE 11

DRAINAGE IMPROVEMENT COSTS

Line	Construction Cost W/O Catch Basins $	Catch Basins $	Construction Cost Total $	Project Cost Total $
Main N	263,500	4,500	268,000	348,400
Lat. N1	34,100	3,000	37,100	48,200
Lat. N2	108,700	12,000	120,700	156,900
Lat. N2-1	17,900	3,500	21,400	27,800
Lat. N2-2	29,600	5,500	35,100	45,600
Lat. N2-3	5,800	2,000	7,800	10,100
Lat. N2-4	6,000	2,500	8,500	11,100
Lat. N2-5	6,000	2,500	8,500	11,100
Lat. N3	34,200	4,500	38,700	50,300
Lat. N4	80,200	5,000	85,200	110,800
Lat. N4-1	10,700	2,000	12,700	16,500
Lat. N4-2	9,900	2,000	11,900	15,500
Lat. N5	5,200	1,000	6,200	8,100
Lat. N6	139,900	8,000	147,900	192,300
Lat. N6-1	43,500	6,500	50,000	65,000
Lat. N6-2	9,600	2,000	11,600	15,100
Lat. N6-3	4,800	2,000	6,800	8,800
Lat. N7	22,700	3,000	25,700	33,400
Main H	147,000	1,000	148,000	192,400
Lat. H1	13,400	3,500	16,900	22,000
Lat. H2	257,900	0	257,900	335,300
Lat. H2-1	86,400	5,000	91,400	118,800
Lat. H2-1-1	25,600	3,000	28,600	37,200
Lat. H3	305,000	13,000	318,000	413,400
Lat. H3-1	54,100	4,000	58,100	75,500
Lat. H3-2	38,800	4,000	42,800	55,600
Lat. H4	147,000	10,000	157,000	204,100
Lat. H5	128,400	8,500	136,900	178,000
Lat. H6	20,300	3,000	23,300	30,300
Lat. H7	93,600	3,500	97,100	126,200
Lat. H7-1	5,900	1,500	7,400	9,600
Lat. T1	68,000	8,500	76,500	99,500
Lat. T1-1	32,600	4,000	36,600	47,600
Lat. T1-2	13,900	2,000	15,900	20,700
Lat. T2	98,000	8,000	106,000	137,800
Lat. T3	29,800	5,000	34,800	45,200
Lat. T3-1	14,000	2,000	16,000	20,800
Lat. T4	39,100	4,500	43,600	56,700
Lat. T4-1	8,300	1,000	9,300	12,100
TOTALS	$2,459,400	$166,500	$2,625,900	$3,413,800

DRAINAGE POLICY
AND FINANCIAL PLAN

CHAPTER VI
DRAINAGE POLICY AND
FINANCIAL PLAN

PAST PRACTICES

All of the existing drainage facilities in Tualatin have been constructed as necessary, but secondary, parts of other projects. The numerous culverts and storm drains crossing Interstate 5 and Interstate 205 were constructed as part of these freeways. The other culverts in Tualatin were installed as a part of either road or railroad construction. Although the existing storm drains in the Tualatin core area were constructed so long ago that no record exists of the conditions under which they were constructed, it appears that these drains were constructed by both private land owners and by a public agency as part of a road improvement project.

In recent years some storm drains have been constructed to serve new subdivisions. The entire cost of constructing these drains has been borne by the developer. These were built with few established regulations for the construction of storm drains. The City of Tualatin required that all storm drain plans be submitted to the City for review and approval prior to construction. At first the City retained a consulting engineer to review storm drain submittals, but this work is now performed by a full time City Engineer.

The review and approval system, supplemented with extensive negotiations between the land developer and the City, generally resulted in satisfactory storm drainage systems for the developments that they served. (The exceptions are described in Chapter II). From the standpoint of drainage for adjacent properties, however, this system has been less than successful. Land developers did not study the future needs of adjacent properties. Too often insufficient capacity was included in storm drainage systems to serve upstream properties, and little or no consideration was given to the effect of storm flows on downstream properties and drainage systems. The City staff has had neither the information nor regulations necessary to review the relationship of individual storm drainage systems to the larger drainage needs of the area.

The City of Tualatin recognized the need for a drainage plan for the City and surrounding area, and on September 21, 1971, instituted a special building permit fee to be used to finance the preparation of a master drainage plan and to make drainage improvements to the extent that revenue permits. The building permit fee schedule requires a drainage fee of $100 be paid for each new single family dwelling and about one cent per square foot of impervious surface (e.g. roofs, driveways, etc.) for all new buildings other than single family dwellings. This building permit fee for drainage was instituted as a short term source of revenue to finance the preparation of the drainage plan presented in this report and was intended to be modified or eliminated in accordance with the Council's actions following the submission of this report.

FLOOD PLAIN DEVELOPMENT

According to Tualatin River flood projections of the Corps of Engineers, as described in Chapter II of this report, the core area of the City of Tualatin is highly vulnerable to flooding of the Tualatin River. A flood of 100-year frequency would have a high water level of elevation 124.5 at the Boones Ferry Road bridge. Downstream this same flood would result in slightly lower water levels, and where the Tualatin River crosses the county line, the high water level for a 100-year flood is elevation 123.8. The Tualatin area can expect little relief from proposed Tualatin River flood control projects and no relief from Willamette River projects.

Because of the threat of serious flooding in the core area, consideration should be given to special zoning or building requirements to reduce the possibility of property damage or personal injury from high water. Prohibition of all building in the flood plain is probably the surest way to reduce the risk, but since property owners in Tualatin have already established a pattern of building in the flood plain, this would be a drastic measure. A more reasonable approach might be to require that all new buildings be constructed above some minimum accepted level. This approach would have the inherent problem of matching the higher, new sites to the lower, existing sites.

Because the degree of protection that the Council and the core area property owners feel is justified can only be established after public discussion and hearings on the subject, this report does not recommend specific measures. Only when the community decides at what frequency it can tolerate the intrusion of flood water, can appropriate regulations be adopted.

The possibility of more affirmative flood control action should not be ignored by the City.

An engineering investigation directed solely at flood control and protection for Tualatin appears to be justified. The cursory review of flood conditions included in this drainage plan indicates that flood relief for Tualatin is most likely to come from downstream channel improvements to the Tualatin River and possibly from a system of dikes in the Tualatin area.

IMPROVEMENT PRIORITIES

After reviewing existing drainage problems, proposed improvements, cost estimates, and net benefits to the City of Tualatin, this report recommends the following order of priorities for drainage improvements.

Priority No. 1: Lateral N4 from Nyberg Creek to Avery Road.

As shown on Plate 4, this storm drain intercepts flow from a recently constructed 24-inch drain on Avery Road and routes the storm flow down a natural swale east of Boones Ferry Road. The proposed storm drain crosses Sagert Road and then enters Boones Ferry Road about 300 feet north of Sagert Road. The drain then continues north along Boones Ferry Road to Nyberg Creek. From Avery Road to Boones Ferry Road the storm drain would be on private property except at the Sagert Road crossing, and many storm drain easements will be required.

The primary purpose of this storm drain is to intercept storm flows from the new Navajo Hills subdivision and keep these storm waters out of the roadside ditch along Boones Ferry Road. The storm drain essentially returns Navajo Hills runoff to its natural drainage path. Since the south part of Navajo Hills was originally in another basin, this storm drain will serve slightly more land than is naturally tributary to the drainageway. A secondary benefit will be realized when the storm drain replaces a presently inadequate drain line under and north of Sagert Road. On Boones Ferry Road, about 500 feet south of Nyberg Creek, the east roadside ditch is so deep that it is a public menace. The proposed storm drain in this area will allow the ditch to be filled.

Priority Number 1 is unusual in that it is recommended more for the public safety benefits that will result from the project than for the protection of property and the reduction in public inconvenience that normally accrue from drainage projects.

Priority No. 2: Lateral N6 from the existing swale 200 feet south of Sagert Road to Avery Road.

This drain is a part of the solution to the existing drainage problems in Galway Hills. Between the upper end of this proposed storm drain and Galway Hills, however, there is almost 1,900 feet of private land presently proposed for subdividing. Since City policy requires that subdividers construct on-site improvements, including drainage improvements, Priority Number 2 calls for the City to construct the required storm drain from the north boundary of the proposed subdivision to a suitable disposal point.

The existing drainageway flows in a ditch along 93rd Street, crosses Sagert Road, enters a diversion box on the northside of Sagert Road and then normally goes thru a drain tile beneath a cultivated field. When the flow is too great for the drain tile, the storm water overflows the diversion box and flows across the cultivated field. The landowner, Mr. Itel, has threatened legal action against the City because of storm flow across his land. Even though the storm water follows a natural drainage path across the property and the property owner's claim for damages appears to be weak, it would not be prudent for the City to aggravate this existing grievance by knowingly increasing storm flow across the property. The proposed storm drain therefore is routed around the Itel property and discharges into an existing swale east of the property and about 200 feet north of Sagert Road. With approval from the property owner, a less costly drain could be constructed across the property along the route of the natural drainageway. Ultimately, it is proposed that this drain be extended north about 700 feet to the drainage ditch on the south side of the existing railroad tracks.

Priority Number 2, in conjunction with drainage improvements on a proposed subdivision, will correct existing drainage problems at Galway Hills and will eliminate storm drainage through the agricultural drain tile north of Sagert Road at 93rd Street.

Priority No. 3: Nyberg Creek, Boones Ferry Road crossing.

With the increased flows resulting from the improvements in Priority Number 2, the existing culvert that crosses Boones Ferry Road and discharges into Nyberg Creek will soon be overloaded. The proposed improvement is a 54-inch diameter storm drain to be constructed east from the lower end of the drain proposed in Priority Number 1, across about 100 feet of private property to the east right-of-way of the Oregon Electric Railroad tracks. This short storm drain would intercept flow from the drainage ditch that flows east along the south side of the railroad tracks.

Priority No. 4: Main N along Avery Road east of Oregon Electric Railroad.

Along this section of Avery Road the ditch on the south is unusually large. It has to be large because much land to the south drains to this ditch, and even though the runoff is from undeveloped land, there are occasionally large storm flows in the ditch. If this land to the south is developed, as is presently contemplated for part of the land, the storm runoff will be too great to be safely conveyed in a roadside ditch.

The proposed storm drain would convey runoff west on Avery Road and discharge it north of Avery Road into a drainage ditch on the south and east side of the Oregon Electric Railroad. The existing roadside ditch flows west along Avery Road and empties into a ditch south of Avery Road that goes under the railroad tracks and into Hedges Creek. Since the existing culvert under the railroad tracks is not large enough for future storm flows and the existing route does not conform to natural drainage patterns, it is proposed that runoff to this section of Avery Road be routed north to follow the predominate land gradient.

Priority No. 5: Lateral N2 from Nyberg Creek to Nyberg Road, and Lateral N2-1.

Lateral N2 is proposed to eventually serve the entire commercial area between 80th Avenue, Boones Ferry Road, and Nyberg Road. Priority Number 5 proposes that Lateral N2 first be constructed from Nyberg Creek to Nyberg Road. At this point it can receive flows from the south side of the new K-mart parking lot and will be available to serve as a drainage outlet for future improvements to Nyberg Road.

Lateral N2-1 has a relatively small area draining to it and will serve primarily to drain Nyberg Road between the freeway and 80th Avenue. It is included as a priority project because several factors point to this section of Nyberg Road quickly reaching full development and being in need of wider pavement, curbs, and drainage facilities.

Future Priorities. The need for drainage facilities moves with land development. For this reason most of the drainage improvements proposed in this drainage plan have not been given a priority position. It is intended, rather, that the City annually review drainage improvement priorities in light of the City's future development patterns.

CONSTRUCTION STANDARDS

Construction standards are preceded by, and usually controlled by design standards. Recommended design standards are included in Chapter III of this report, along with some technical references that describe the engineering considerations necessary for the application of design standards. Although it is a recommendation of this report that the City of Tualatin adopt the design standards presented in this report, the construction of a satisfactory storm drainage system is heavily dependent upon the quality of engineering that goes into future drainage projects.

Since the engineering on future drainage projects will probably come from many different engineers retained by either the City or private land developers, the City Engineer should review and approve all drainage projects. These reviews can be expedited, and there can be some design continuity, if all engineers submit copies of analyses and computations to the City Engineer. Along with the clear and complete plans and specifications, all drainage project submittals should include the following:

1. A map showing the area(s) tributary to the project.
2. Computations of storm flows from both off-site and on-site lands.
3. Profiles of all proposed storm drains and major drainage channels.
4. Computations of drain and open channel capacities.
5. Computations showing trench and live loads on drain pipes.
6. Computations of street gutter and catch basin capacities.
7. Discussion of downstream drainage conditions as related to the proposed project.
8. Description of any variations from the Tualatin Drainage Plan and justifications for variations.

All drainage improvements must, by law, be designed by a professional engineer, registered in the State of Oregon.

Contract specifications should utilize the Standard Specifications for Public Works Construction prepared by the Oregon Chapter of the American Public Works Association. Some consulting engineering firms have specifications comparable to the APWA specifications and the City Engineer should have the option of allowing specifications other than APWA standards.

Construction details for the major items in a storm drain system should conform to the following:

1. Pipe. Storm drain pipe should be concrete, clay, or asbestos-cement. Minimum storm drain pipe size should be 12 inches in diameter. Mortar or open joints may be permitted if full gravel

bedding and pipe zone is used. Rubber gasketed joints should be required within root zones of existing trees and where gravel bedding and pipe zone is not used.

2. Manholes. Manholes should conform to the Standard Manhole Details of the Oregon Concrete Pipe Manufacturers Assocation.

3. Manhole Frames and Covers. Manhole frames and covers should conform to drawing number 45 of the Standard Drawings for Public Works Construction prepared by the Oregon Chapter of the American Public Works Association.

4. Catch Basins. Catch basins including the grates and frames should conform to the Standard Concrete Inlet Details of the Clackamas County Department of Public Works, and should include a one foot deep basin below the outlet pipe. These are the details of the Oregon State Highway Department and are widely used throughout the state.

BUILDING SITE DEVELOPMENT

The addition of a dwelling to vacant land can create a significant storm water discharge where none existed previously. Some of the storm runoff will come from driveways and patios, but most will come from roof drains. On closely developed lands, zones R7 and R10 for instance, storm flows from one property can cause a nuisance and possibly property damage to adjacent property, if allowed to be indiscriminately discharged.

The best way to avoid discharging surface runoff to adjacent properties is to grade all properties to drain toward the street. This is not always possible but should be encouraged by the City, wherever site conditions permit. Regardless of the site grading, roof drainage should not be allowed to discharge to adjacent private property. The City should require that roof drains be routed to either a roadside ditch, street gutter, or storm drain. The City should not permit roof drains to be discharged to a storm drain across private properties unless an easement is granted to the City along the entire route of the drain.

FINANCIAL CONSIDERATIONS

Storm drainage projects are traditionally very difficult to finance. The basic problem is lack of public support. There are many characteristics of drainage projects that make them less likely to garner public support than other municipal utility services. First, the victims of inadequate drainage are usually a minority of an area's voters and land owners. Second, storm drainage facilities are infrequently utilized. This is particularly true when advanced planning is involved and facilities are sized for a peak storm that will occur sometime after the area has reached full development. Third, storm drainage facilities are necessarily large and usually expensive. And finally, it is difficult to devise a revenue raising plan for storm drainage projects that relates to individual benefits.

Revenue Options. An ideal revenue system for drainage projects would be one that levies a charge to a property in proportion to that property's contribution to downstream drainage problems. Under such a system undeveloped land would pay considerably less than highly developed land. In fact, since completely undeveloped land has the same runoff characteristics now that it had before the surrounding area was settled, it logically should not be charged for drainage improvements for other properties. If undeveloped land should not be burdened with drainage cost, then developed land must carry most or all of the costs.

There are many commonly used taxes, charges and fees that bear more heavily on developed properties. Property taxes, being proportionate to land and improvement value, are normally heavier on developed property. They also tax the speculative value of land and thereby tax vacant land more for future use than for present development. Since drainage projects are constructed to meet the future needs of land, there is some justification in a tax system, such as the property tax, that charges more for potentially developable vacant land than it charges for lower value agricultural land. No matter how much logic there is to using property taxes to finance property improvements, the present property tax system is too heavily loaded with the costs of schools and local governments to make it a revenue option that the public will accept.

The costs of drainage improvements could be derived by a surcharge on the user fees of some other utility. The most expedient utilities to carry the surcharge would be the City owned sewer system or water system, but a surcharge could also be levied on power, gas, telephone, or any other utility that operates under a City franchise. Such a fee would bear solely upon occupants of developed land, but any other correlation between utility use and storm drainage is difficult to imagine. Although utility surcharges have been advocated to finance drainage improvements in other communities, they have been considered and rejected in this plan because a relationship cannot be demonstrated between utility use and storm drainage needs.

The present City policy of using building fees for storm drainage improvements has several points of merit. It places a levy directly upon building and thereby relates revenue to the cause of future drainage problems. It is proportional to the area of impervious surface to be installed, and thereby varies approximately in proportion to the future increase in storm runoff from the property. Also, it does not require present residents to pay for improvements to serve future property developers and residents.

There are many ways that a building permit fee for drainage projects can be applied. The fee can be uniformly applied to all building in the City, based upon improvement costs, the way most common building fees are levied. The fee for drainage can be applied throughout the City, based upon the area of impervious surface, the way the present Tualatin drainage fee is levied. Since the cost of routing drainage from a building site to a suitable point of disposal (in this case the Tualatin River) varies according to many factors, the drainage fee for buildings could logically vary for each drainage basin, or sub-basin or even each property. The latter would be the ultimate in relating drainage costs to drainage benefits, but it would be so complex as to be unworkable.

Of the building fee options considered, increasing the City's building fee is recommended. The building permit drainage fee would be based on cost of the improvement and would replace the present fee that is based upon area of impervious surface. Although a fee based upon improvement value loses some of the close relationship between cost and benefit inherent in the other building fee options, it has the advantage of ease of application and strong legal precedent supporting its use.

Financing Options. If Tualatin could meet its present and future drainage needs from building permit revenues as they are received, there would be no need to consider methods of financing drainage projects. Hopefully, someday Tualatin will be able to construct drainage improvements on a pay-as-you-go system, but now there are too many existing drainage needs to delay construction until enough building permit fees are collected. Funds will have to be borrowed to construct the priority improvements.

A municipal agency can borrow funds from traditional lending institutions by issuing bonds. These bonds may be retired over a 10- to 25-year period by revenue from the utility improvement, in this case building permit fees, or by ad valorem property taxes. A bond that is supported only by revenue from a utility is known as a revenue bond. A bond that is backed by property taxes is a general obligation bond. With a revenue bond all that is pledged as security is the revenue of a utility, but with a general obligation bond, the voters of an area have, in fact, pledged their property as collateral.

General obligation bonds are usually easily sold to the local banking institutions. The saleability of revenue bonds, however, depends on the utility, its area of service, its record of service, its financial stability, the present and future demand for its service and other factors that generally indicate its ability to retire the bonds using revenue. If the proposed drainage improvements are measured by the above considerations, they will be rated so low as to make revenue bonds unmarketable.

Even though general obligation bonds are backed by property and property taxes, it is not mandatory that property taxes be used to retire the bonds. These bonds may be retired by building fee revenues the same as with revenue bonds. Property taxes would only be used when building fees were insufficient to meet current bond obligations.

General obligation bonds are easy to sell, carry low interest rates, and offer some flexibility in the method of repayment. However, general obligation bonds must be approved by the voters. For drainage improvements passage of a bond issue will probably require more voter education and encouragement than for some of the more direct service utilities, such as for water or sewer system improvements. The fact that revenue for the bonds will come from future residents, through building fees, should make the financial burden on present voters negligible; and if this point is emphasized, the bond issue should receive voter approval.

Property Assessments. The previous two sections have discussed methods of raising revenue for the drainage obligations of the entire City and methods of borrowing funds to construct drainage improvements. Many drainage improvements, however, will specifically benefit one area of the City and will be supported by a limited number of property owners, rather than the entire city.

There are state laws that permit properties to be formed into an assessment district for the single purpose of constructing a predetermined improvement. This procedure is frequently used in the construction of street improvements and sanitary sewer extensions.

The assessment district would be formed by action of the City Council, and the Council would also act as the governing body. The City would contract for preparation of the plans and specifications and for construction of the improvements. The total costs of the project would be proportioned among the benefited properties in the improvement district and levied as assessments or liens against the properties. (The term "assessment," as used in this context, refers to a charge to a property and should not be confused with a county assessor or with the work he does in appraising the value of properties).

Property owners may pay the entire assessment in cash upon receipt of final notice, or they may apply for time payments under the Bancroft Act. If the Bancroft option is chosen the owner will make semiannual payments to the City for up to 20 years. The effective annual interest charged on the unpaid balance cannot be greater than 7 percent. The City will receive the funds necessary for construction by selling bonds on behalf of those property owners that have applied for time payments. Voter approval is not required for the sale of Bancroft Bonds. The bonds are supported by the improvement liens on the properties and by the owners' commitment to make payments, as recorded in the applications for time payment.

For drainage improvements that are both of local and of general benefit, the City may support assessment district projects with City funds to the extent that it deems justified. Assessment districts are a commonly used and effective method of constructing improvements where a close relationship between costs and benefits can be demonstrated. Unfortunately, this relationship is often difficult to establish for storm drainage projects.

Federal Grants. The Department of Housing and Urban Development has a program that provides funds for up to 50 percent of construction costs for sanitary sewer laterals, water system improvements, and storm drainage improvements. Unfortunately, the limited funds are allocated first to sanitary sewers, second to water improvements, and last to storm drainage improvements. Since requests for sanitary sewer and water projects have exceeded available funds, there essentially has been no grant program for storm drainage improvements.

There is a possibility that future funding of the HUD program will allow grants for storm drainage projects, but this chance appears to be remote. Until the available funds are substantially increased, even the effort of applying for a storm drainage grant does not appear to be justified. From a previous HUD water project, the City of Tualatin discovered that just applying for these grant funds requires the submission of a voluminous document. Although some of the material from the previous application could be reused, a grant application to HUD is not a task that can be taken lightly.

Serial Levy. Some communities use a serial levy to support drainage improvements. This is a pay-as-you-go property tax. For a serial levy voters approve a specified rate of property taxation (e.g. \$0.50 per \$1,000 of true cash value per year) of a specified amount of taxation for a specified period of time, usually two to ten years. In addition to requiring voter approval the serial levy has the disadvantage that it would not raise the immediate funds necessary to correct existing drainage problems. It would also bear heavier on existing residents than on future residents.

RECOMMENDED FINANCIAL POLICY

Responsibilities for drainage are varied and frequently difficult to define. Storm water is one of the oldest sources of conflict between neighbors, and frequently these conflicts reach a court of equity. While past court actions give some guides for storm water control policy, many cases have revolved around specific and peculiar points that cannot be translated into general policy, and some court actions have been inconsistent in the resolution of comparable conflicts. Regardless of the problems of developing legally defensible drainage policies, it appears that the City of Tualatin will be better served by the adoption of reasonably equitable and definable drainage policies than by disavowing a general policy and attempting to individually resolve drainage disputes.

Property Owner Responsibilities. Recommended policies directed toward the responsibilities of individual property owners are as follows:

1. Property owners shall be responsible for maintaining existing natural drainageways across their properties.

2. The fact that property developments have resulted, or will result, in storm drainage flows greater than that which has previously been experienced in a natural drainageway does not relieve a property owner of his responsibility for maintaining that drainageway. The exception to this is drainage basins where the upstream drainage area has been substantially increased. (This may be disputed. There are existing threats of court action centering around these conditions, but any policy that limits drainage rights to only the flow quantities that have historically been experienced, in effect, closes all existing drainageways for use in a drainage system.)

3. Owners of undeveloped property may take whatever action they deem necessary to protect

their property from storm flows, provided that such action does not change the points of entry to, or exit from, the property, or change the velocity of flow at the points of entry or exit.

4. Property owners or developers that subdivide or otherwise commercially develop their property shall be required to install drainage improvements to serve the ultimate drainage needs of the property, in accordance with the plans and guidelines presented in this report.

5. Property owners and developers may be required to extend their drainage improvements up to a maximum of 200 feet from the lowest point on their property. (If a drainage improvement longer than 200 feet is required, the City will be responsible for its installation).

6. Property owners or developers that subdivide or otherwise commerically develop property shall compensate the City of Tualatin for all on-site drainage improvements that the City may have made to the property. (There will be some cases where the City will have to make improvements to drainageways on undeveloped land in order to accommodate an upstream drainage system. Since these improvements are an obligation of the owner, the City should be reimbursed for these costs when the land is developed.)

City Responsibilities. Policies that define the responsibilities of the City of Tualatin in the area of storm drainage are as follows:

1. The City will assume the cost of constructing drainage improvements along public rights-of-way.

2. The City will be responsible for installing downstream off-site drainage improvements from any property that cannot reach a suitable point for the discharge of storm water within 200 feet of the lowest point on the property.

3. The City will initiate proceedings toward the formation of storm drainage assessment districts wherever property owner support appears to justify such action.

4. The City will be responsible for maintaining storm sewers and ditches on public rights-of-way or easements granted to the City and shall enforce the requirement that drainageways on private land be maintained by the property owner.

5. The City's responsibilities for storm drainage are secondary to its budgetary limitations, and these responsibilities can only be assumed to the extent that funds permit.

Although the financial plan presented in this report foresees the City collecting drainage revenues at a rate sufficient to meet drainage needs, it is possible that a development will require more costly downstream off-site drainage improvements than City funds will permit. In these cases the City will have to either deny permission to develop until City funds are available or use funds from the developer to construct the necessary drainage improvements. In the event a developer's funds are used to meet City obligations, the City should agree to repay the developer from the first available drainage funds. If the City finds itself consistently without drainage funds, it is an indication that the revenue rate has been set too low and that it should be increased.

Responsibilities of Other Government Agencies. The County, State and Federal road building agencies are the only groups that are involved in storm drainage in Tualatin, other than the City and the Tualatin landowners. Even though the City of Tualatin cannot always impose its policies on these other government agencies, the City should exert every available source of influence to assure that all road drainage systems in the Tualatin area are constructed to serve the ultimate drainage needs of the area, in accordance with the plans and guidelines presented in this report.

FINANCING PLAN

Project Costs. The project costs presented in Chapter V include the costs of drainage improvements on private land, the costs of drainage improvements on public rights-of-way, and the costs of storm drains that are required for road improvement projects. These road improvement drains are defined as roadway drains that are designed to carry flows less than 10 cubic feet per second. In order to develop a plan for financing drainage improvements on public rights-of-way, the costs of this type of work must be isolated. Table 12 shows the project costs presented in Table 11 divided between private projects, City projects, and road improvement projects.

Revenue Source. Of the available revenue sources, an increased building permit fee has most of the desirable characteristics previously discussed. It places the burden of future improvements on future developments, it can be administered within an existing program, future available revenue can parallel future drainage needs, and it is feasible (i.e., the necessary building permit fee will not be a burden that impedes future development.)

The present building permit fee schedule has a graduated scale that starts at $10 per $1,000 of improvement value and decreases to $1.00 per $1,000 of improvement value for improvements values over $100,000. A plan check fee equal to 50 percent of the building permit fee is added to the building permit fee schedule thereby increasing it 50 percent above the rates given above. A new home with an improvement value of $25,000 now pays a building permit fee of $89.00 plus a plan check fee of $44.50 for a total of $135.50.

TABLE 12
PROJECT COST ALLOCATIONS

Project	Private Projects $	City Projects $	Road Projects $
Priority Projects			
Lateral N4			
0+00 to 36+30		110,800	
Lateral N6			
7+00 to 31+00		105,000	
Main N			
Boones Ferry Rd. Crossing		14,200	
Main N			
141+60 to 166+30		88,000	12,300
Lateral N2			
0+00 to 8+60		34,200	
Lateral N2-1			
0+00 to 9+20			27,800
Priority Subtotals	None	$352,200	$40,100
Non-Priority Projects			
Main N			
0+00 to 10+10	7,100		
Nyberg Road Crossing		17,100	
10+60 to 19+60	9,700		
Meridian Rd. X-ing		700	
20+30 to 44+30	32,900		
I-5 Crossing		2,100	
46+30 to 75+80	133,200	1,000	
77+30 to 141+80	30,300		
Lateral N1		48,200	
Lateral N2			
8+60 to 21+75		88,900	
21+75 to 33+10			33,800
Lateral N2-2			45,600
Lateral N2-3			10,100
Lateral N2-4			11,000
Lateral N2-5			11,000
Lateral N3			
0+00 to 16+05	20,000		
16+05 to 21+35		16,300	
21+35 to 26+30			14,000
Lateral N4-1			16,500
Lateral N4-2			15,500
Lateral N5		8,100	
Lateral N6			
0+00 to 7+00	17,900		
31+00 to 49+60	69,300		
Lateral N6-1			
0+00 to 8+50		32,500	

8+50 to 20+50			32,500
Lateral N6-2			15,100
Lateral N6-3			8,800
Lateral N7			
0+00 to 7+00		23,300	
7+00 to 10+70			10,200
Main H			
0+00 to 21+30	0		
Boones Ferry Rd. & R.R. X-ing		29,900	
22+40 to 137+10	145,400	11,000	
Tual.-Sher. Rd. X-ing		6,100	
Lateral H1		8,000	14,000
Lateral H2	335,300		
Lateral H2-1		118,800	
Lateral H2-1-1		37,200	
Lateral H3			
0+00 to 50+40		386,000	
50+40 to 60+40			27,400
Lateral H3-1			
0+00 to 4+00		19,600	
4+00 to 23+50			55,900
Lateral H3-2		55,600	
Lateral H4			
0+00 to 35+70		192,000	
35+70 to 40+00			12,100
Lateral H5			
0+00 to 24+60		169,500	
24+60 to 28+10			8,500
Lateral H6			
0+00 to 8+30		23,100	
8+30 to 10+80			7,200
Lateral H7			
0+00 to 25+70	97,600		
25+70 to 28+90		17,600	
28+90 to 32+95			11,000
Lateral H7-1			9,600
Lateral T1		99,500	
Lateral T1-1			
00+00 to 8+00		26,300	
8+00 to 16+00			21,300
Lateral T1-2			
0+00 to 3+20		11,600	
3+20 to 6+40			9,100
Lateral T2		137,800	
Lateral T3		45,200	
Lateral T3-1			20,800
Lateral T4			56,700
Lateral T4-1			12,100
Non-Priority Subtotal	$898,700	$1,633,000	$489,800
TOTAL	$898,700	$1,985,200	$529,900
TOTAL OF ALL PROJECTS		$3,413,800	

In order to support the drainage improvement program presented in this report, the building permit fee should be doubled. The plan check fee would not be included in the increase and would therefore have to be redefined as being 25 percent of the building permit fee. Under the proposed schedule the building permit fee for a new home with an improvement value of $25,000 would be $178.00, plus a plan check fee of $44.50, for a total of $22.50. The increase of $89.00 would be for drainage improvements.

For a single family dwelling a charge of $89.00 is less than the recently enacted drainage charge of $100 for each single family dwelling. The present drainage fee schedule, however, is proportionately much lower for commercial and multi-family developments than it is for single family dwellings. These commercial and multi-family developments will, therefore, experience a higher drainage fee under the proposed system. With the enactment of the proposed building permit fee increase, the present drainage fee ordinance should be repealed.

The revenue that will be available from the building permit fee increase is not easy to project. Building permit fees have increased from a total (excluding plan check fee) of $920 in 1967 to $17,800 in 1971. This is an average increase of over 100 percent per year during the last 4 years. Obviously such a growth rate cannot be maintained. For the same period, the total assessed value of the Ctiy of Tualatin has increased an average of 34 percent per year. This increase, though more modest than the building permit increase, is still much larger than the City can expect to maintain.

For the present fiscal year, 1972-73, the total assessed value of the City is $34,596,000. Since the year is not over, the total value of building in the City and the total building permit fees are unknown. Based upon the records of recent years and the data available for 1972 we have estimated that the 1972-73 building will have a value of $8,131,000 with a resultant permit fee revenue of $28,900, excluding plan check fees. Projections in this report use the 1972-73 data as a base, with a 30 percent increase in assessed values and building values in 1973-74. Thereafter, the percent of increase is projected to decrease uniformily to an annual increase of 10 percent between 1976-77 and 1977-78. The 10 percent annual increase is then maintained for the remaining years of the projection.

The projected revenue for drainage projects, as shown in Table 13, is $37,600 in 1973-74, the first year of the program, and increases to $114, 800 in 1982-83. This means that the proposed revenue source could support annual drainage improvement expenditures of $37,600 in the first year, and this could be increased each year thereafter.

Financing. An annual budget of $37,600 for drainage improvements is substantial but, even with the projected revenue increases, it would take six to eight years to raise the funds necessary to construct the priority projects. Some of the priority projects could be delayed, but most of these projects are necessary now. The estimated cost of all priority projects to be constructed from drainage funds in $352,200.

Since federal grant funds are unavailable and revenue bonds are unsaleable, the City of Tualatin must look to a general obligation bond issue for financing. This requires voter approval. A bond issue of $350,000 would permit the immediate construction of all priority projects. If this bond issue carried a five percent effective annual interest rate, it could be retired in 20 years, with an average total debt service payment of about $27,900 per year.

An annual pyament of $27,900 per year is well within the projected revenue available from increased building permit fees and would permit the City to meet some non-priority drainage needs as they arrive. In fact, since the revenue is projected to rise and the debt service will remain approximately constant, in the future there will be more and more funds available to support projects that cannot now be given a priority position.

Although a plan that uses a modest debt payment with a substantial annual budget is flexible and conservative, it should be noted that this, like all pay-as-you-go plans, will be undermined by increasing construction costs. If construction costs rise an average of six percent per year during the 20 year life of the bond issue, a construction dollar at the end of the bond period will only buy one-third as much as it will buy in 1973.

If funds can be borrowed at five percent interest and construction costs increase six percent per year, a rational case can be made for borrowing as much as possible and constructing as many drainage improvements as funds permit. This, however, persupposes an unalterable growth projection and requires an inflexible commitment to future debt that few responsible citizens would be willing to make. Even though the modified pay-as-you-go plan proposed for Tualatin may cost more than a plan that relies heavily on debt, the flexibility and low risk of the proposed Tualatin financial plan are benefits that more than compensate for any losses due to increasing construction costs.

TABLE 13
PROJECTED DRAINAGE FUND REVENUE AND EXPENDITURES

Fiscal Year	Debt Service on $350,000 Bond Issue	Annual Improvements, Construction Cost $	Construction Cost Discounted 6%/yr. from 1973-74	Building Permit Fee Revenue
73-74	27,900	9,700	9,700	37,600
74-75	27,900	19,000	17,900	46,900
75-76	27,900	28,500	25,400	56,400
76-77	27,900	36,900	31,000	64,800
77-78	27,900	43,400	34,400	71,300
78-79	27,900	50,500	37,700	78,400
79-80	27,900	58,400	41,200	86,300
80-81	27,900	67,000	44,600	94,900
81-82	27,900	76,500	48,000	104,400
82-83	27,900	86,900	51,400	114,800
83-84	27,900	98,400	54,900	126,300
84-85	27,900	111,000	58,500	138,900
85-86	27,900	124,900	62,100	152,800
86-87	27,900	140,200	65,700	168,100
87-88	27,900	157,000	69,400	184,900
88-89	27,900	175,500	73,200	203,400
89-90	27,900	195,800	77,100	223,700
90-91	27,900	218,200	81,000	246,100
91-92	27,900	242,800	85,100	270,700
92-93	27,900	269,900	89,200	297,800

Table 13 shows both the proposed drainage improvement construction budget for each year and the equivalent value of the same work in terms of the 1973 construction costs, upon which the cost estimates are based. It is apparent that future construction expenditures will not be as significant in terms of today's dollars as the projected costs might indicate. During the twenty-year period that is projected in Table 13 all of the priority projects, and two-thirds of the non-priority projects, could be constructed from projected revenues. This rate of drainage improvement construction appears to be compatible with the rate at which drainage needs will arise.

Financial Summary. The proposed financial program for the Tualatin drainage plan calls for a $350,000 general obligation bond issue to be retired entirely from revenue that the City can receive by doubling the present building permit fee. No property taxes would be required. The total cost of all drainage improvements proposed by this plan is about 3.4 million dollars. One half million dollars of this would be for road drainage improvements and would come from road improvement funds. About $900,000 would be for improvements on private property and would be the obligation of property owners. The remaining two million dollars in drainage improvements would be constructed by the City of Tualatin. The proposed financial plan could support 1.4 million dollars in drainage improvements over the next 20 years. This would be 70 percent of the improvements recommended in this drainage plan for construction by the City and although this does not completely implement the plan in 20 years, it does coincide with projected drainage needs.

SUMMARY AND RECOMMENDATIONS

CHAPTER VII
SUMMARY AND RECOMMENDATIONS

SUMMARY

As Tualatin continues to change from a rural community to a suburban community, the storm drainage problems that it now experiences will become more numerous and acute. Drainage problems will come from two facets of growth. With growth will come streets, buildings, and parking lots that repel surface runoff. These improvements will replace the present open fields and swamps that now absorb and detain surface flows. Other problems will arise from the desire of property owners and developers to obstruct or alter existing drainageways so their land will be more suitable for building sites.

Presently, the predominate method of drainage in Tualatin is through open channels, supplemented by culverts at road crossings. The drainage system recommended in this report calls for continued use of open channels along major drainageways, such as Hedges Creek and Nyberg Creek, and the phased construction of storm sewers in place of existing roadside ditches and small drainageways across private property. These improvements would be constructed (1) as part of street improvements, (2) by property owners, and (3) by the City as part of a drainage improvement program.

The core area of the City of Tualatin is vulnerable to flooding by the Tualatin River. Proposed flood control projects on the Tualatin River will offer negligible flood relief to the City of Tualatin. Flood control projects on the Willamette River will have no effect whatever. Since the City will be unable to undertake extensive flood control projects of its own, the City should establish special zoning and building regulations to reduce the effect of flooding.

This report recommends that property owners be responsible for maintaining existing drainageways across their property, so that they will satisfactorily transport present and future storm water flows. Properties that are subdivided or commercially developed should be required to install drainage facilities sufficient to carry runoff from the ultimate development, in accordance with the plans and guidelines presented in this report. The City of Tualatin should assume responsibility for constructing all drainage facilities within the public rights-of-way.

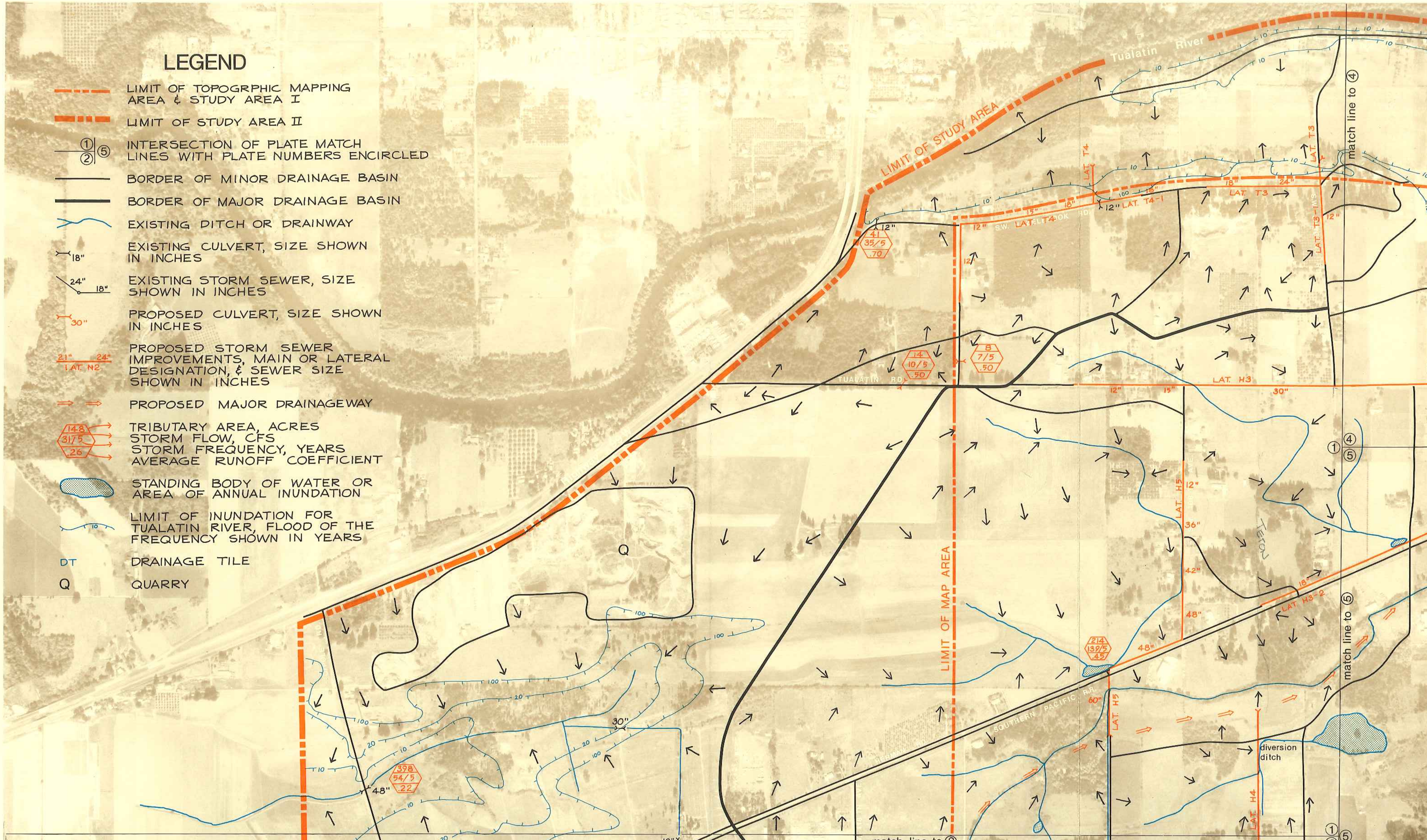
The total cost of all drainage improvements proposed in this report is $3.4 million, of which the City of Tualatin would be responsible for about $2 million. The proposed financial plan foresees completion of about 70 percent of the City's drainage obligations within the next 20 years. The City's share of the project can be financed by doubling the present building fee. Property taxes or other special levies will not be required. In order to correct existing drainage problems, the financial plan calls for a general obligation bond issue of $350,000. The bond issue can be retired in 20 years from projected building permit fees. Most of the remaining drainage improvements can be constructed on a pay-as-you-go basis from the fees that are received in excess of debt service on the bonds.

RECOMMENDATIONS

Based upon the findings of this report, we recommend that the Tualatin City Council take the following actions:

1. Hold a public meeting to present the Tualatin Drainage Plan and to receive questions and comments on the Plan.
2. Amend the Tualatin Drainage Plan, if necessary, based upon the information and opinions presented at the public meeting.
3. Adopt the Tualatin Drainage Plan as the drainage policy of the City of Tualatin.
4. Adopt an ordinance calling for a 100 percent increase in the present building permit fee, and at the same time repeal the present ordinance relating to drainage fees.
5. Adopt an ordinance defining property owner responsibilities for maintaining drainageways on private property.
6. Seek voter approval for a $350,000, 20-year, general obligation bond issue.
7. If the bond issue is approved, initiate the preparation of plans and specifications for construction of the priority drainage projects.
8. Sell the bonds.
9. Call for bids and award construction contracts.
10. If the bond issue fails to receive voter approval, proceed with drainage improvements in order of their priority as fee revenues permit.
11. At a council meeting, or special public meeting, review the flood danger in the City of Tualatin for the purpose of establishing suitable zoning and building requirements to reduce the risk of property damage or personal injury.
12. Have the City Engineer review the feasibility of engaging the Corps of Engineers or a private engineering firm to study flood protection improvements in the Tualatin area.

FIGURES AND PLATES



KEY MAP

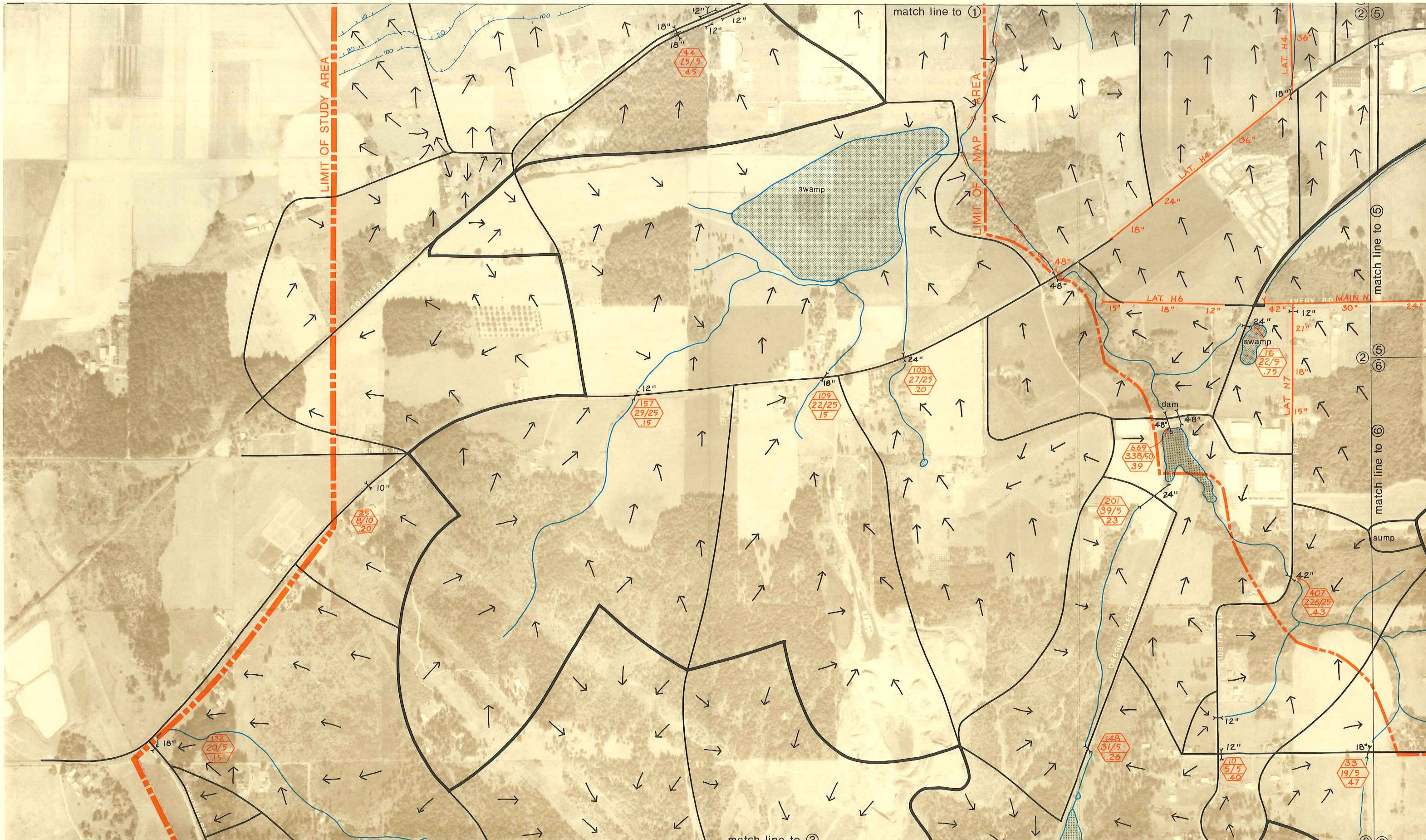
PREPARED FOR THE CITY OF TUALATIN, OREGON BY R. A. WRIGHT ENGINEERING, PORTLAND, OREGON

TUALATIN DRAINAGE PLAN

north

0' 400' 800'

PLATE 1



KEY MAP

FOR LEGEND SEE PLATE 1

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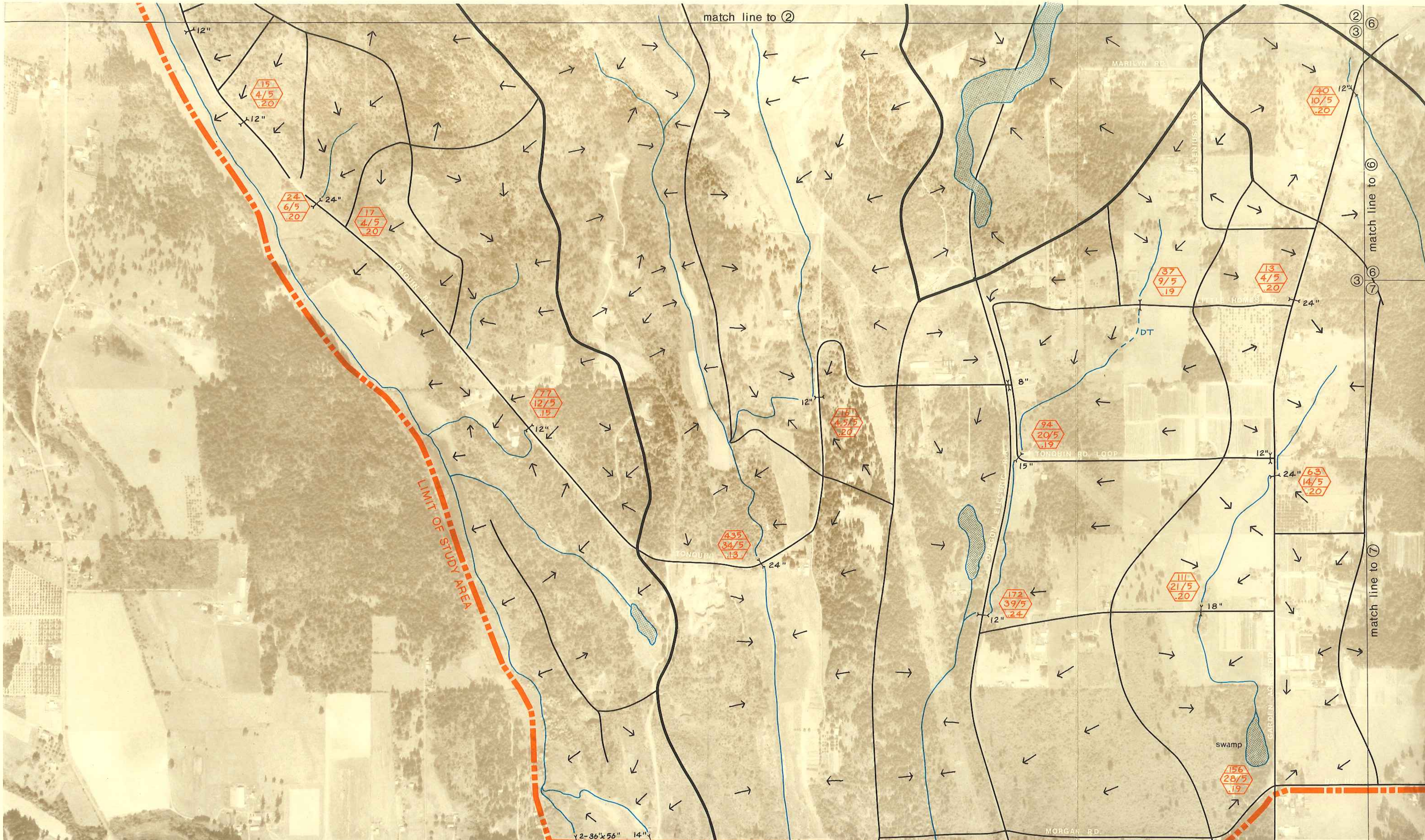
TUALATIN DRAINAGE PLAN

north

0' 400' 800'

PLATE 2



KEY MAP

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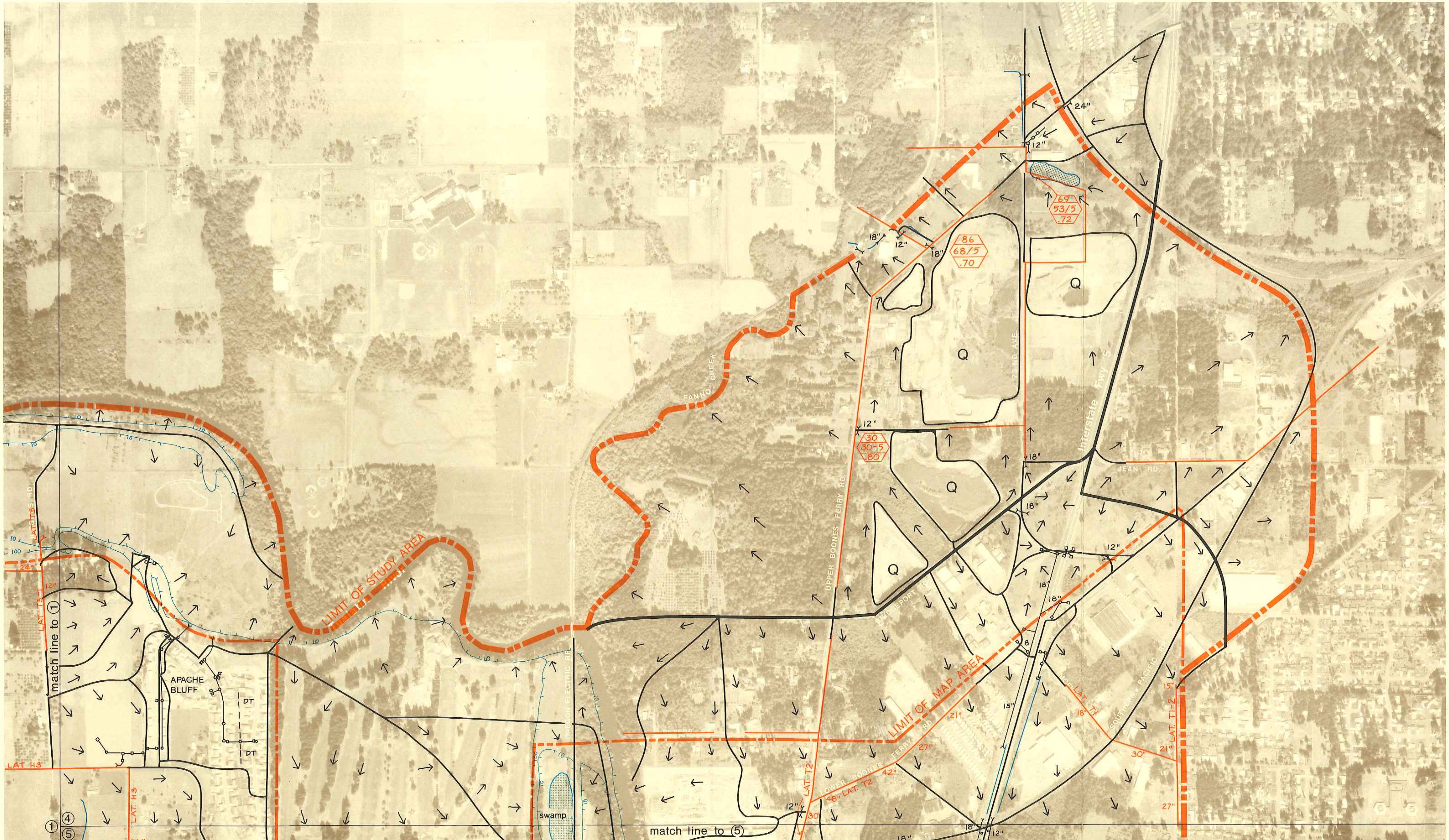
TUALATIN DRAINAGE PLAN

north

0' 400' 800'

PLATE 3



KEY MAP

FOR LEGEND SEE PLATE 1

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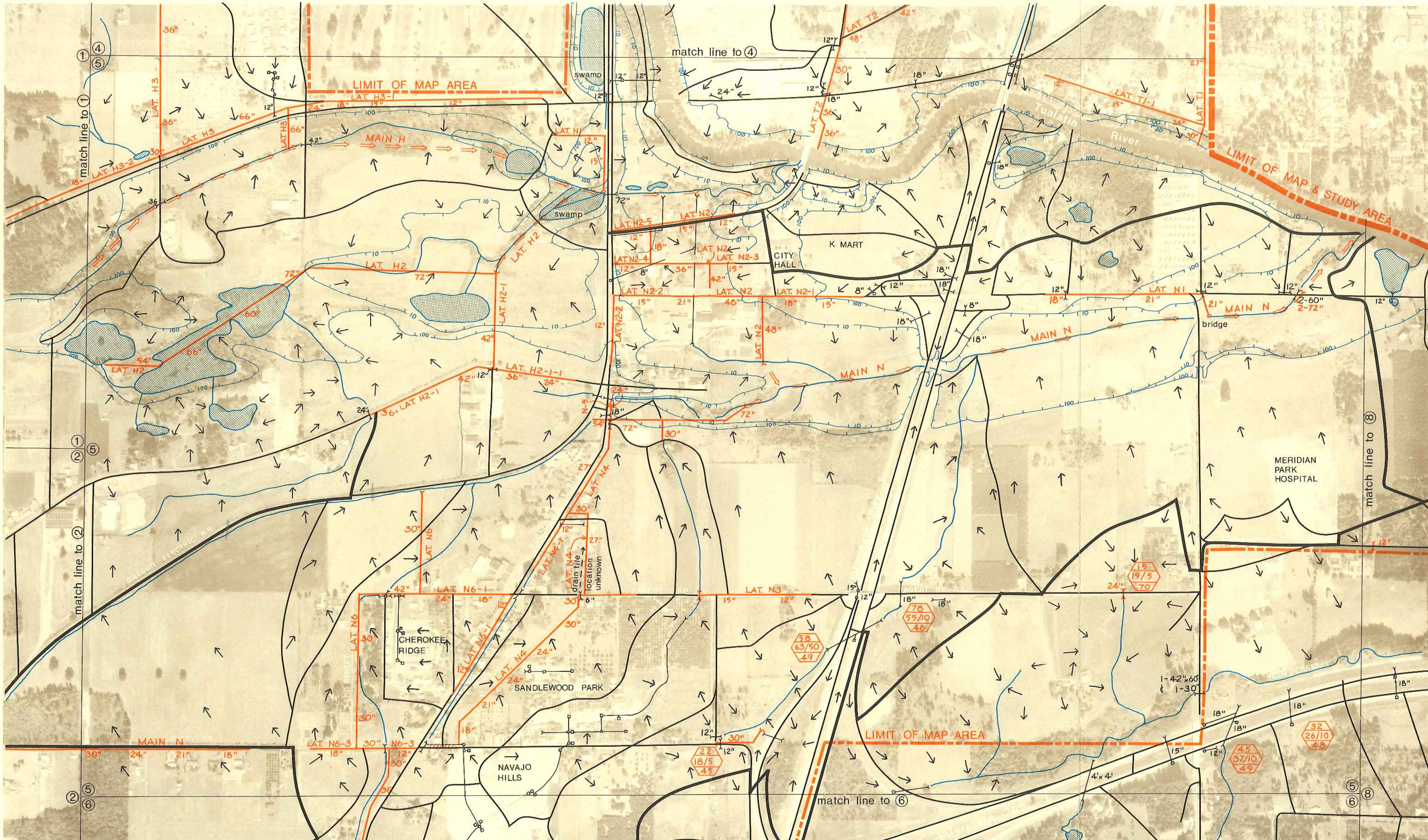
TUALATIN DRAINAGE PLAN

north

0' 400' 800'

PLATE 4



KEY MAP

FOR LEGEND SEE PLATE 1

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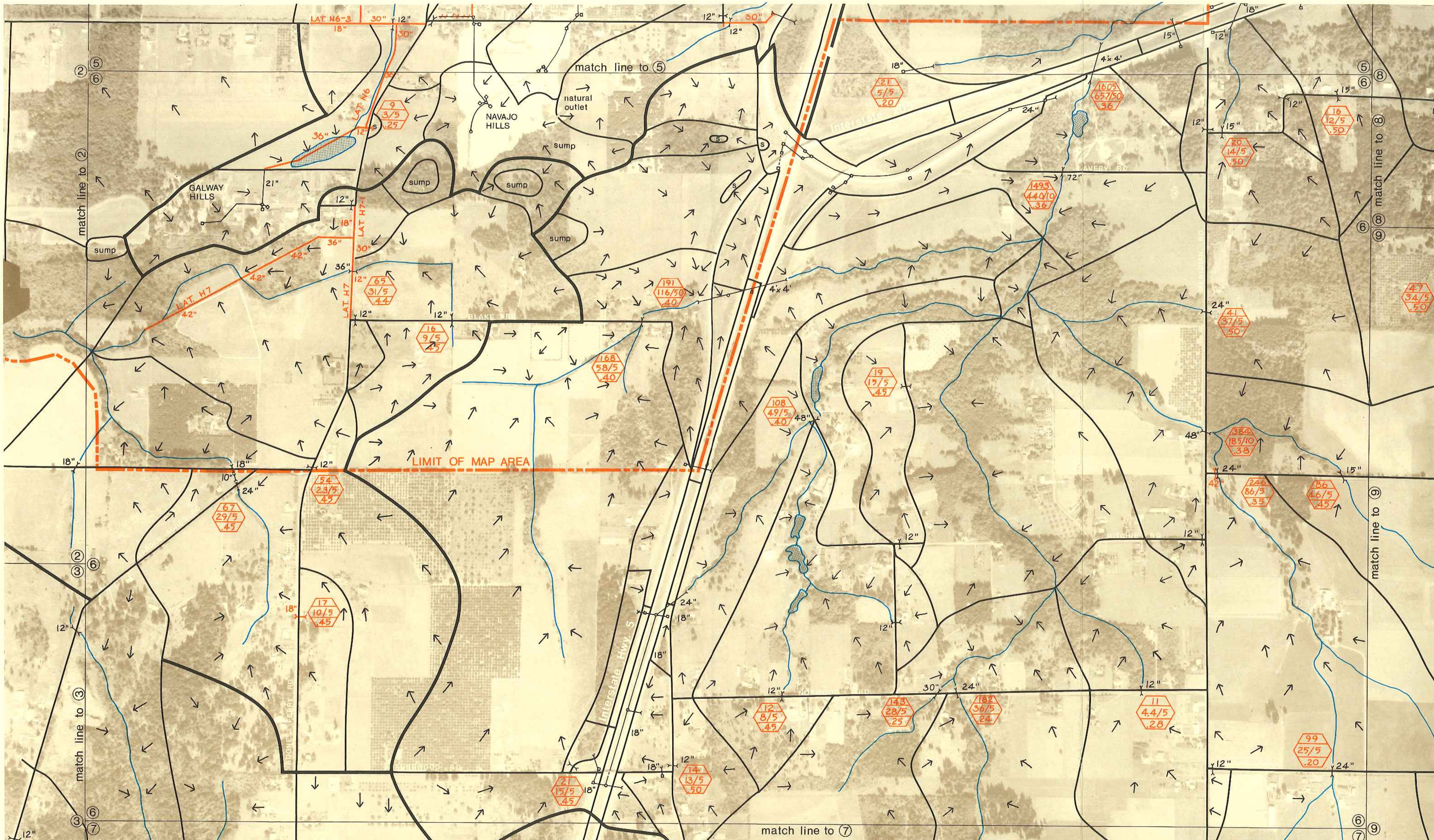
TUALATIN DRAINAGE PLAN

north

0' 400' 800'

PLATE 5



KEY MAP

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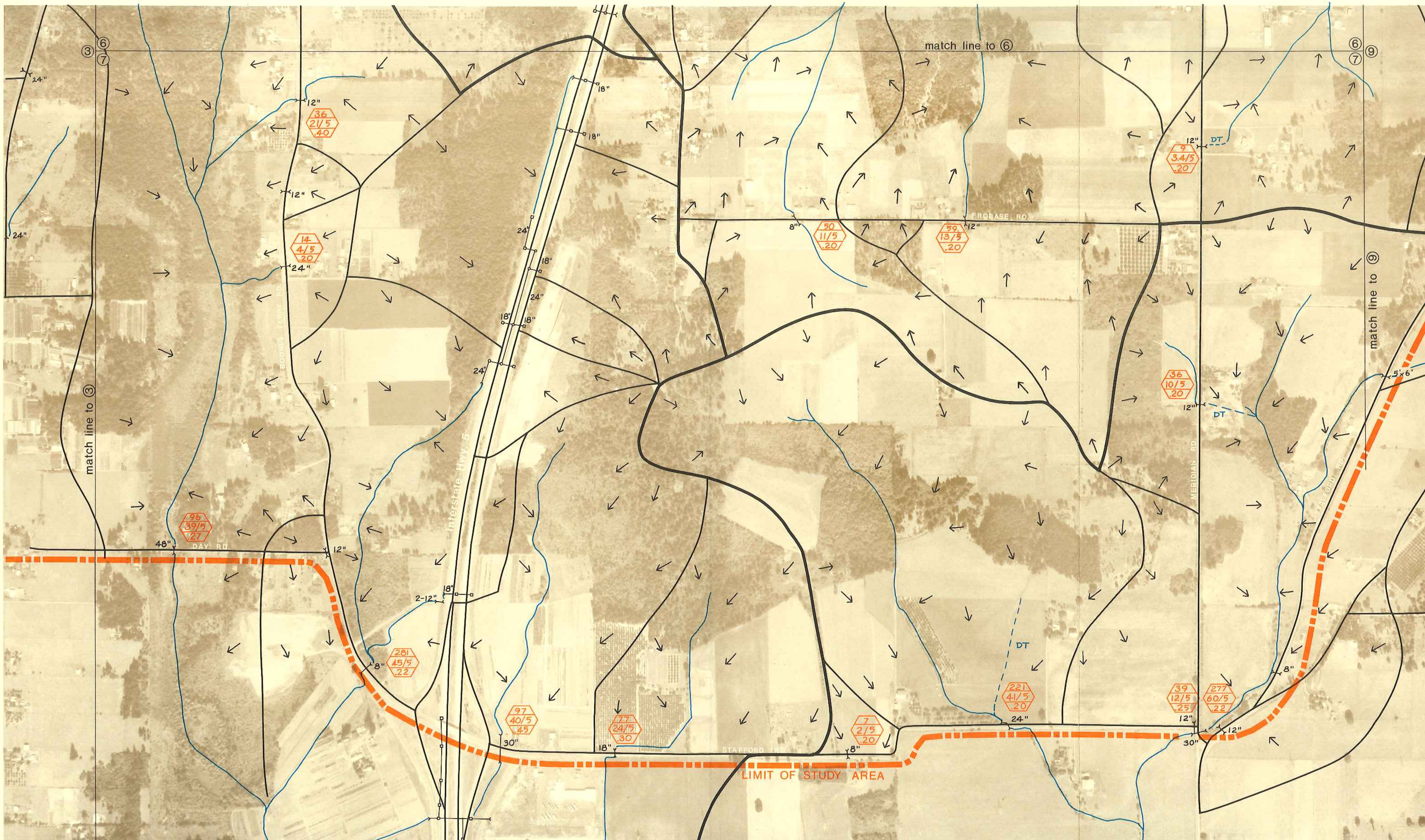
TUALATIN DRAINAGE PLAN

north

0' 400' 800'

PLATE 6



KEY MAP

FOR LEGEND SEE PLATE 1

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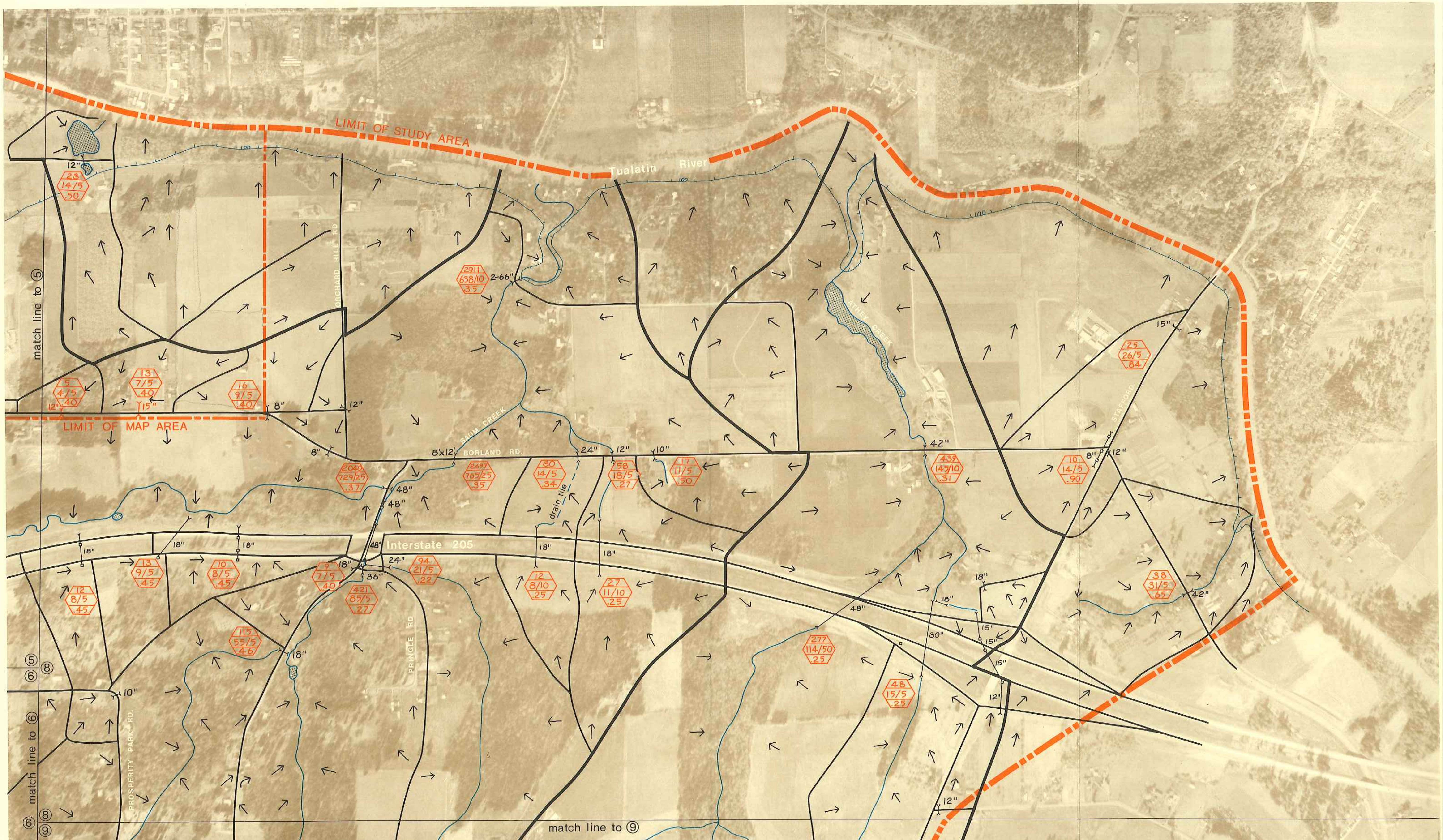
TUALATIN DRAINAGE PLAN

north

0' 400' 800'

PLATE 7



KEY MAP

FOR LEGEND SEE PLATE 1

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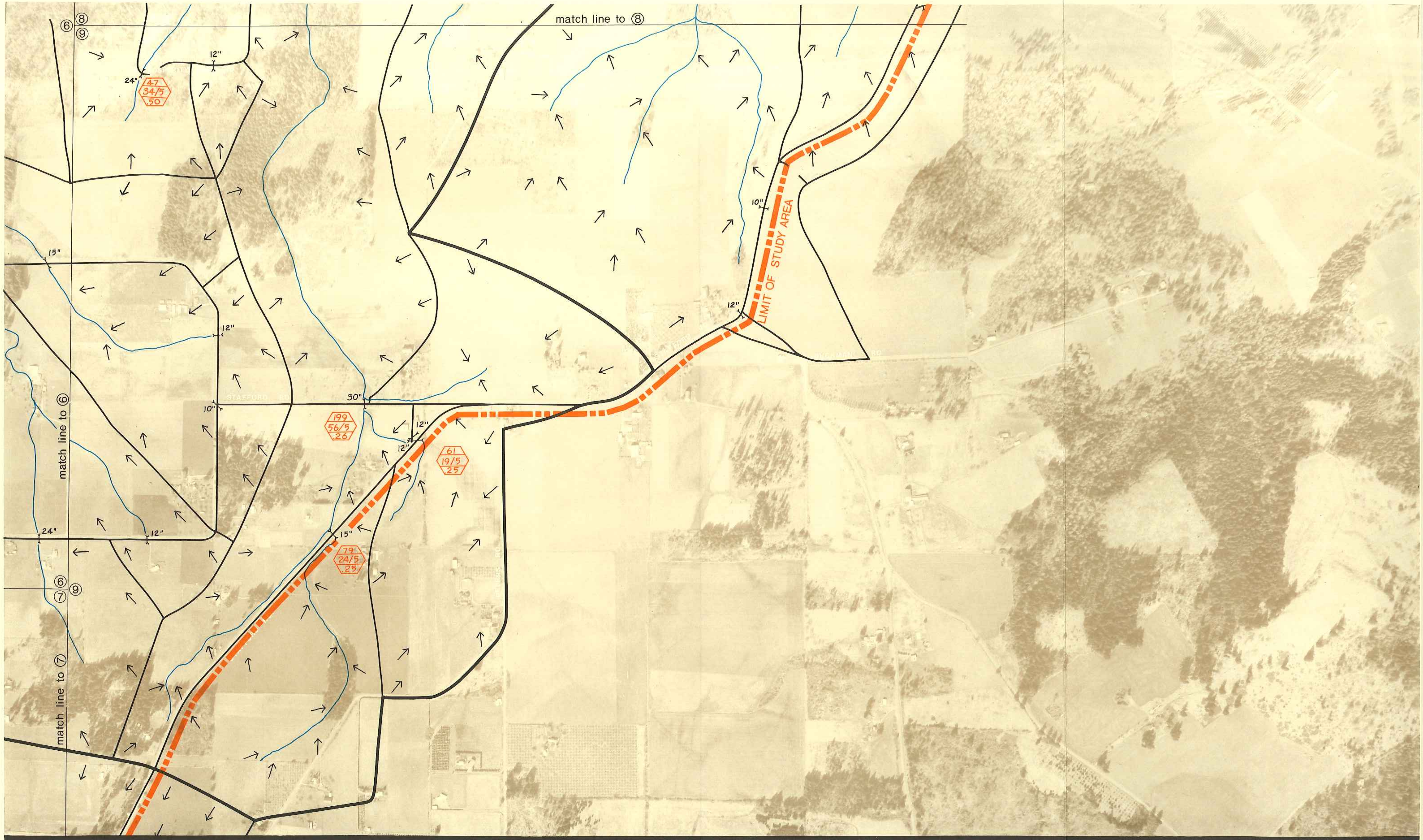
TUALATIN DRAINAGE PLAN

north

0' 400' 800'

PLATE 8



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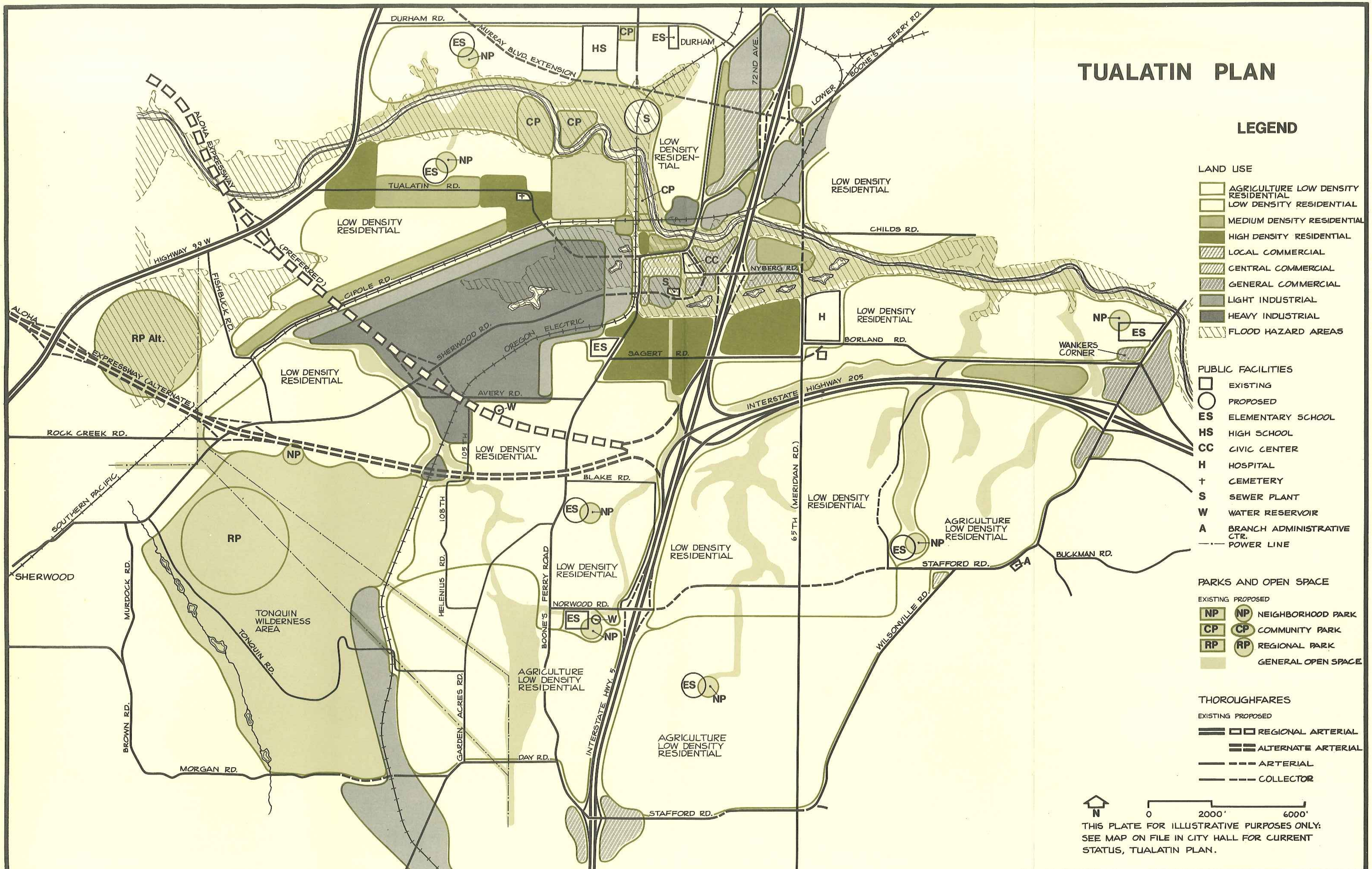
TUALATIN DRAINAGE PLAN

PLATE 9

APPENDIX


TUALATIN PLAN
LEGEND
LAND USE
AGRICULTURE LOW DENSITY RESIDENTIAL
LOW DENSITY RESIDENTIAL
MEDIUM DENSITY RESIDENTIAL
HIGH DENSITY RESIDENTIAL
LOCAL COMMERCIAL
CENTRAL COMMERCIAL
GENERAL COMMERCIAL
LIGHT INDUSTRIAL
HEAVY INDUSTRIAL
FLOOD HAZARD AREAS
PUBLIC FACILITIES
EXISTING
PROPOSED
ES ELEMENTARY SCHOOL
HS HIGH SCHOOL
CC CIVIC CENTER
H HOSPITAL
† CEMETERY
S SEWER PLANT
W WATER RESERVOIR
A BRANCH ADMINISTRATIVE CTR.
POWER LINE
PARKS AND OPEN SPACE
EXISTING PROPOSED
NP NEIGHBORHOOD PARK
CP COMMUNITY PARK
RP REGIONAL PARK
GENERAL OPEN SPACE
THOROUGHFARES
EXISTING PROPOSED
REGIONAL ARTERIAL
ALTERNATE ARTERIAL
ARTERIAL
COLLECTOR
N
0 2000' 6000'
THIS PLATE FOR ILLUSTRATIVE PURPOSES ONLY: SEE MAP ON FILE IN CITY HALL FOR CURRENT STATUS, TUALATIN PLAN.
DURHAM RD.
MURRAY BLVD. EXTENSION
DURHAM
72 ND AVE.
LOWER BOONE'S FERRY RD.
ALOHA EXPRESSWAY
TUALATIN RD.
HIGHWAY 99 W
FISHBUCK RD.
(PREFERRED)
CIPOLE RD.
SHERWOOD RD.
OREGON ELECTRIC
CHILDS RD.
NYBERG RD.
BORLAND RD.
SAGERT RD.
WANKERS CORNER
INTERSTATE HIGHWAY 205
ALOHA
EXPRESSWAY (ALTERNATE)
RP Alt.
AVERY RD.
ROCK CREEK RD.
105 TH
BLAKE RD.
65 TH (MERIDIAN RD.)
SOUTHERN PACIFIC
SHERWOOD
RP
108 TH
MURDOCK RD.
TONQUIN WILDERNESS AREA
TONQUIN RD.
HELENIUS RD.
BOONE'S FERRY ROAD
NORWOOD RD.
STAFFORD RD.
BUCKMAN RD.
WILSONVILLE RD.
GARDEN ACRES RD.
INTERSTATE HWY. 5
BROWN RD.
MORGAN RD.
DAY RD.
AGRICULTURE LOW DENSITY RESIDENTIAL
LOW DENSITY RESIDENTIAL

R.A.Wright
engineering