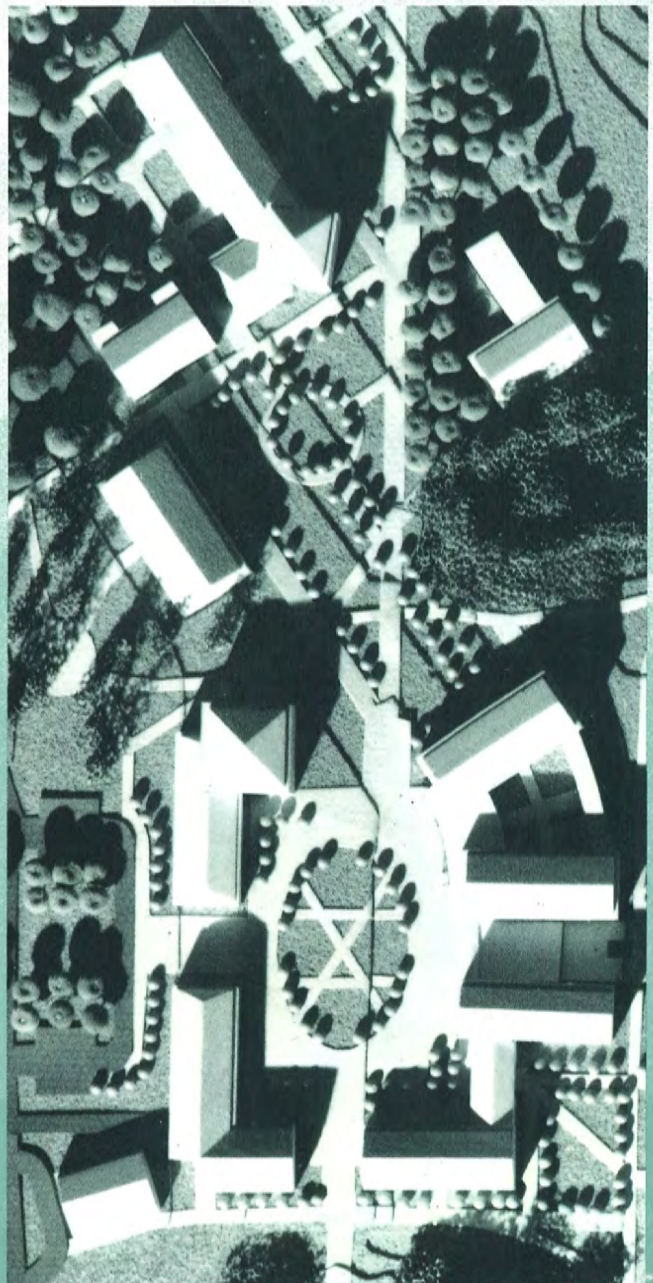


# *Vancouver Campus Master Plan Appendix*



## WETLANDS

### EXISTING ENVIRONMENT

**Introduction.** The WSU property contains several wetlands and streams. Although virtually all of these areas have been heavily disturbed in the past, many are currently providing valuable environmental functions and need protection from potential impacts related to campus development. The wetland areas discussed here are areas which meet the definition of wetlands according to current federal, state, and county regulatory agencies.

In general, wetlands on the property can be divided into three groups; (1) highly degraded small wetlands on the upper terraces, (2) degraded but functioning wetlands along the lower terraces, and (3) wetlands and riparian areas associated with Mill Creek. Most of the wetlands on the property occur along the lower terraces and Mill Creek.

Potential impacts to these areas, due to campus development, are of two types. First, there will be direct impacts where access roads, parking, or structures will be constructed within wetland boundaries. The campus design attempts to minimize these impacts. Second, and more significant, are potential indirect impacts to wetlands which are well out of the area of campus development. The primary indirect impact is the potential loss of large wetland areas due to diversion of their sources of water. Careful design of stormwater management facilities, however, can minimize or avoid this impact.

### Background

For the purpose of identifying wetlands under the U.S. Army Corps of Engineer's jurisdiction, wetlands are formally defined as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (Environmental Laboratory 1987). Many of the areas currently regulated as wetlands have been severely degraded or modified over time. These areas bear little resemblance to



swamps or marshes. Other wetland areas, such as wet meadows, have always been at least seasonally dry. Although in some cases these areas still meet the requisite criteria for a wetland determination, many such areas have been so degraded by agriculture and urbanization that they cannot be recognized as a jurisdictional wetland except by an expert. Such areas occur on the Washington State University (WSU) Vancouver Branch Campus site.

The determination of the locations and boundaries of jurisdictional wetlands on the WSU property relied on the criteria and methods described in the 1987 *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987). Application of the 1987 Manual was also conditioned on recent guidance and clarification provided by the Seattle District Corps of Engineers (Corps 1991 1992a and 1992b).

Although slightly different criteria for defining wetlands are used by different agencies, virtually all wetlands, regardless of the method used to delineate them, have the following diagnostic environmental characteristics:

- 1) **Hydrophytic Vegetation.** The vegetation in wetlands is dominated by plants typically adapted to, or at least capable of surviving under, conditions of prolonged surface soil wetness. These so-called hydrophytic plant species are able to survive despite the presence of anaerobic conditions in the upper part of the soil (due to waterlogging) for prolonged periods during the growing season. "Anaerobic" refers to the absence of free oxygen, in this case in the upper part of the soil where most plant roots are, during at least a portion of the growing season. Most upland plants do not occur in these conditions. The indicator status of specific plants (whether hydrophytic or not) is recorded in Reed (1988).
- 2) **Hydric Soils.** Surface soils in wetland areas exhibit morphological characteristics indicative of formation under the anaerobic conditions associated with prolonged waterlogging. That is, "hydric" soils are either especially rich in organic matter and therefore characteristically black in color (such as peat or muck soils) or, if they are predominantly mineral soils, they generally exhibit an

overall gray color with associated bright mottles (distinct blotches of contrasting color). Mineral hydric soils which are, or were once, waterlogged for very long periods of time are "gleyed." These soils are generally bluish gray or greenish gray in color. These and other very wet soils often emit a hydrogen sulfide (rotten eggs) odor.

- 3) **Wetland Hydrology.** Wetlands are either permanently or seasonally inundated to a shallow depth (shallow enough to allow the growth of rooted emergent plants such as cattails) or, in wetlands which are supported by ground water, are saturated to the surface for a prolonged period during the growing season. In this region "surface saturation" is currently taken to mean that the near-surface water table must remain continuously within 12 inches or so of the surface for at least two weeks during the growing season. According to the most recently available guidelines, the technical growing season is taken to extend from February 11 through December 1 in the Vancouver area (McGee 1972, Environmental Laboratory 1987, Corps 1991 1992a 1992b).

Under normal circumstances, all three of these diagnostic characteristics must be present for an area to be considered a jurisdictional wetland. Some uncultivated wet pasture areas are colonized by grasses and other plants which still qualify them as regulated wetlands while others are clearly dominated by plants believed to be more typical of nonwetlands (Reed 1988). These last areas may not technically qualify as wetlands unless they are wet enough during the early part of the growing to be recognized as seasonal wetlands. Such areas at least temporarily support a prevalence of wetland vegetation before they begin to dry out.

**Regulatory Environment.** Jurisdictional wetlands are "waters of the United States" which are regulated under Section 404 of the federal Clean Water Act. Lakes and streams of any size (even intermittent streams) are also waters of the United States under Clean Water Act jurisdiction. Federal jurisdiction of rivers and streams not bordered by wetlands extends up to the ordinary high water mark (generally the top of the recognizable channel bank).

Following the federal lead, a number of state agencies now regulate streams and wetlands to varying degrees.

The state Department of Ecology (WDOE) regulates activities in wetlands and other state waters through its implementation of Section 401 of the federal Clean Water Act. Most permits required to alter wetlands cannot be obtained without 401 water quality certification from the state.

The state Departments of Fisheries and Wildlife (WDOF and WDOH) can also regulate streamside wetlands through the Hydraulic Project Approval (HPA) process. The WDOH and WDOF prefer to rely on the 1989 Manual when evaluating wetlands in the context of implementing the HPA. However, this evaluation applies only to wetlands adjacent to fish-bearing streams.

The state Shoreline Management Act regulates activities within 200 feet of the shoreline of streams having a mean annual flow greater than 20 cubic feet per second. The Shoreline Permit program, administered by the county, insures some level of regulation of wetlands associated with streams of this size by dictating the nature of development in waterside areas. Lands adjacent to lower Mill Creek on the WSU Campus site are regulated under the Shoreline Management Act.

Federal policy excludes from regulation many cultivated wetlands which have been at least partly drained (Corps 1990). State and local agencies generally follow suit in not exerting jurisdiction over such areas. Other cultivated areas which were originally wetlands may have now been drained to the point that they no longer exhibit wetland hydrology (i.e. the water table no longer persists near the soil surface for a sufficiently prolonged period). These locations, altered by legal farming practice, are now technically nonwetlands and are excluded from regulatory jurisdiction, even if plugging or breaking the drain tiles would restore wetland hydrology. Deliberately draining a wetland in an attempt to avoid federal regulation is illegal.

**Clark County Wetlands Protection Ordinance.** Clark County now regulates wetlands through its Wetlands Protection Ordinance (Chapter 13.36 of the Clark County Code). The ordinance establishes a five-tiered wetlands ranking system based on perceived functions and values. The ranking ranges from Category 1

wetlands, which represent the highest quality areas (e.g. large forested wetlands) to Category 5 wetlands, which are highly degraded areas that are typically dominated by weedy vegetation and are often hard to distinguish from nonwetlands.

The ordinance also stipulates "base" buffer widths based on category and provides replacement (mitigation) ratios if the subject wetland is to be altered. Buffers are upland zones around wetlands or streams which act to cushion these sensitive areas from adverse impacts generated beyond their boundaries. Base buffer widths, which can be adjusted downward by enhancing the quality of the buffer (e.g. through extra planting), range between 300 to 50 feet for the highest and lowest quality wetlands, respectively. Category 5 wetlands require no buffer.

Artificial wetlands, Category 5 wetlands, and other wetlands below a minimum size are exempted from the provisions of the ordinance. A Wetlands Permit is required if certain regulated activities are planned to occur within non-exempt wetlands. These activities include impacting more than one acre of wetland, discharging 50 cubic yards or more of material into a wetland, building a structure in a wetland, and destroying wetland vegetation.

Any permitted impacts to a wetland must be mitigated through wetland creation or restoration. The created or restored wetland must be located within the same watershed as the impacted wetland. In addition, the ordinance stipulates "replacement ratios" (area of created wetland to area of impacted wetland) which range from 6:1 to less than 1:1. These ratios vary depending on the category of the wetland impacted and the type and timing of the replacement. Wetland mitigation projects must be monitored and managed to insure success. In addition, contingency plans are required if the project does not meet the goals specified in the Wetlands Permit.

### **Site Description and Terrain**

Most of the WSU site is comprised of the gently- to moderately-sloping eastern and southeastern shoulder of a hill between Interstate 5 and Salmon Creek. This descends as a series of gently-sloping benches, separated by steeper hillslope

segments, to the terraced valley floor of the mainstem of Salmon Creek. Most of these upland surfaces have been converted to agricultural uses.

The 100-year floodplain of Salmon Creek extends onto portions of the "lower terrace" of the site immediately adjacent to the active channel of Salmon Creek. This lower terrace accommodates portions of Salmon Creek Avenue as well as an old dairy barn and associated buildings. An abrupt terrace scarp slope separates this lower terrace surface from the "upper terrace" which abruptly transitions to the footslope of the broad hillside comprising the western half of the site.

Seven short but generally steep drainageways dissect the benched western part of site, where campus facilities are to be concentrated. No drainageways extend from Salmon Creek or Mill Creek into the smaller eastern campus area. Most of the short tributary drainages are heavily wooded with a mixed deciduous and coniferous forest representing a mainly upland (nonwetland) vegetation association. Three of these ravines drain directly to Mill Creek. The other four drain to the upper Salmon Creek terrace where (together with lower hillside seepage zones or springs) they help to nourish the fairly extensive area of wetlands on the terrace surfaces above Salmon Creek. Discharge from these short tributary channels ultimately makes its way to Salmon Creek, although there are no uninterrupted surface water connections from these tributaries to that stream.

The northern part of Mill Creek meanders within a broad-floored canyon defined by steep sideslopes vegetated by the same upland forest association present in the minor drainages. The floodplain here is wooded and consists of a mainly wetland plant association. The southern stream reach on the property is incised within and confined by an old terrace surface in the valley of Salmon Creek. Floodplain width approximates the width of the active channel in this area. The channel of Mill Creek drops from an elevation of about 165 feet MSL at the north property boundary to about 135 feet MSL at the Salmon Creek Avenue bridge. Average stream gradient is about one percent.

**Surface Soils.** The general soil type prevalent in this area is the Hillsboro-Gee-Odne association. Most of the site is mantled with deep, generally well- or

moderately well-drained and moderately permeable silt loam soils (Hillsboro silt loam and Gee silt loam). In their native condition these soils support upland plant communities typically dominated by Douglas-fir, grand fir, western red cedar, bigleaf maple and vine maple. Ground layer vegetation in such areas consists of nonwetland plants such as swordfern, salal and Oregon grape (McGee 1972).

Most hillside surfaces possessing Hillsboro and Gee soils rarely if ever develop overland flow, even when they are farmed. Overland flow in these areas is even rarer when they are covered with woody vegetation. The inherent permeability of these upland soils usually exceeds instantaneous rainfall intensity. Because of this, precipitation infiltrates the soil rather than ponding and running off the surface. Forest floor litter and root pipes, where present, maintain and encourage a high infiltration rate. Storm runoff in channels draining upland areas is generated by direct channel precipitation, by occasional overland flows developing in very localized hillside concavities, and by shallow subsurface flow from surrounding hillslopes (Harr 1977, Dunne and Leopold 1978, Whipkey and Kirkby 1978, Brooks et al. 1991).

Poorly drained Odne soils, which are wetland soils (SCS 1991a and 1991b) in their undrained condition, are mapped by the SCS as occurring over substantial parts of the site. Cove soils, which are also hydric, are also mapped in a number of areas (McGee 1972). Mapped Odne soil is especially extensive in the vicinity of the BPA right-of-way in the north central portion of the site. However, soil sampling within this mapped Odne area did not support the presence of hydric soil here. Surface soils in this area generally exhibited a dark brown matrix and were unmottled (nonhydric appearance).

Hydric soils occur in conformance with mapped units or as unmapped inclusions in all delineated wetland locations on this site. These are generally dark grayish brown or very dark gray silt loam soils with bright mottles in the surface horizon. The hydric soils of this site are locally underlain by compact, clay-rich, slowly permeable layers which tend to perch water during the rainy season. A few perpetually wet seepage zones and streamside benches possess highly organic or gleyed soils.



**Subsurface Conditions.** Subsurface conditions in the upper, western part of the site conform to those which would support relatively deep percolation in most areas. The capacity of this part of the site for recharge is demonstrated by the distribution of wetlands on the property. Apart from a small area with compact subsoils near NE 29th Avenue, conditions are generally not conducive for wetland formation in the upper part of the property where the main campus is to be built. This is significant to site wetlands because groundwater flow, derived from recharge in this area, supplies the springs, seeps and minor watercourses in the western half of the site. This groundwater reaches the surface where it intersects either the ravines penetrating the hillside or lower hillside surfaces along the valley of Salmon Creek (Parametrix, Inc. 1992).

### **Distribution and Character of Wetlands**

Essentially all wetlands on the WSU Branch Campus site have been substantially degraded by historic farming operations. Impacts include 1) drainage by ditching and tiling of wetland areas in the upper portions of the site, 2) removal of natural vegetation by cultivation, 3) planting of wetlands to crop and pasture plants, 4) pesticide/herbicide applications in cultivated areas, and 5) grazing by cattle in both agriculturally converted wetland areas and in wooded wetlands. In addition to these widespread impacts, a large dairy complex was constructed over an area which was originally at least partly wetland along Salmon Creek Avenue. Despite these past impacts, however, the WSU Campus site continues to support emergent, scrub-shrub and forested wetland areas (Cowardin et al. 1979).

A Washington State Department of Natural Resources (WDNR) Natural Heritage Information System (NHIS) review for records of high quality native wetlands was conducted for this area. The WDNR, while not maintaining a comprehensive state listing, has no records of such wetlands in the WSU Campus area. They also have no records of any endangered, threatened or sensitive plant species in the area. Designated high quality freshwater wetlands included in the NHIS are those which largely retain their native characteristics: their hydrology remains essentially unaltered and they have few if any exotic plant species (WDNR, 1991).

High quality wetlands or rare plants would not be expected in this area because of its long history of agricultural use. A thorough onsite survey of the property revealed no wetlands meeting this definition of high quality wetlands. The presence of rare and endangered plant species is considered highly unlikely and none were observed.

Grazing has recently been confined to the lower terraced area and to wooded locations along the Mill Creek corridor. The floodplain wetland along Mill Creek has also been impacted by changes in channel morphology and hydrology associated with upstream watershed disturbances. Because of channel enlargement, this area no longer appears to be subject to the seasonal flooding and alteration of geomorphic surfaces which would have enhanced wetland and habitat diversity in the bottomland in the past (Petts 1990, Gregory et al. 1991). Horse traffic, off-road vehicle traffic and unrestrained pedestrian use of the area continue to cause impacts to the wetlands in the vicinity of Mill Creek.

The hydrology of onsite wetlands, especially those in the upper part of the property near NE 29th Avenue, has also been impacted by suburban development in hillside areas upslope and to the west of the WSU Branch Campus site. This developed area encompasses a portion of the groundwater contributing area for the upper site wetlands. Stormwater interception and diversion associated with development have probably reduced the water supply for these small isolated wetlands (Winter 1988).

Because of these multiple and sustained impacts, most wetland areas on the WSU Campus site are heavily infested with weedy (exotic) vegetation. For example, non-native forbs such as creeping Charlie (*Glechoma hederacea*), creeping buttercup (*Ranunculus repens*) and stinging nettle (*Urtica dioica*) are dominant over much of the bottomland along Mill Creek because of past grazing. A number of existing or former wetland locations in the upper part of the site have also been partially or completely drained by a combination of ditching, tiling, and enhanced field drainage through land smoothing and surface compaction.

**General Hydrology of Site Wetlands.** The topographic position of most wetland areas on the property indicates that they largely reflect groundwater discharge. The bottomland wetlands along Mill Creek, however, are also supported by direct

streamflow. Groundwater discharge wetlands include the wetlands on the Salmon Creek terrace surfaces and those along the adjoining lower hillside. Some of these lower wetlands maintain perpetually wet conditions, possibly because of the convergence of multiple subsurface flow paths in these locations, while others dry up during the summer. The minor watercourses within ravines penetrating the western uplands are also supported by intercepted groundwater flow.

Groundwater discharge is ultimately supplied by the infiltration of precipitation in the uplands. In this landscape the western uplands act as a local groundwater recharge area and the adjacent lowland acts as a local groundwater discharge zone (Winter 1988, Larson et al. 1989). In our climate, such discharge wetlands are dependent on recharge by heavy precipitation during the late fall and winter (dormant) season (Winter 1988).

Despite the small size of the hillside contributing area, most of the minor watercourses issuing from the wooded ravines apparently support perennial flow. These channels are no more than a few feet wide and a foot or so deep. Shallow flow was observed in all of the channels in August of 1991, despite the very dry year and a prolonged series of drought years in this region. This fact underscores the importance of infiltration, deep percolation and local groundwater recharge to the maintenance of wetlands on this site.

**Lower Hillside/Terrace Wetlands.** The lower flanks of the western hillside and the adjoining terrace surfaces facing Salmon Creek has the largest area of wetland onsite. Most of these areas are disturbed emergent wetlands which, because they currently have adequate hydrology, would revert to higher quality wetland if left undisturbed for a sufficiently long period of time. A few of these wetland areas might be classified by Clark County as Category 3 wetlands in that they have hydrologic circumstances and well-developed wetland soils (and associated soil biota) which would be difficult to replace with mitigation.

The type of vegetation communities occurring in these cattle-impacted areas depends mainly on whether the area is perpetually wet or only seasonally wet. Seasonally wet areas are dominated by velvetgrass (*Holcus lanatus*), foxtail (*Alopecurus pratensis* and *A. geniculatus*), annual bluegrass (*Poa annua*) and wet weedy forbs such as common plantain (*Plantago major*) and cudweed

(*Gnaphalium*). Nonwetland fields in the area are dominated by sweet vernal grass (*Anthoxanthum odoratum*), tall fescue (*Festuca arundinacea*), quackgrass (*Agropyron repens*), bentgrass (*Agrostis tenuis*), clovers (*Trifolium* spp.), dandelion (*Taraxacum officinale*), thistles (*Cirsium* spp.) and other plants typical of pastures in this region.

A few wet pasture areas in the south part of the property did not exhibit a clear prevalence of wetland plants but were nevertheless determined to be wetland because of persistent wetland hydrology during the spring, even after abnormally low rainfall. In some cases, upland grasses were seen to be perched on micro-hummocks which typically result from springtime cattle grazing in wet pastures. The presence of these hummocks is itself a good indicator of wetland hydrology.

Wetter emergent wetland areas in the lower hillside/terrace zone are dominated by the facultative wetland and obligate wetland plants (Reed 1988) typical of sites staying wet near the surface through all or most of the growing season. These are the plants which most people recognize as indicative of wetlands and include species such as soft rush (*Juncus effusus*), water parsley (*Oenanthe sarmentosa*), cattails (*Typha latifolia*), knotweed (*Polygonum*), spikerush (*Eleocharis*), sedge (*Carex*), occasional skunk cabbage (*Lysichitum americanum*), seedbox (*Ludwigia palustris*) and small-fruited bulrush (*Scirpus microcarpus*).

A weedy emergent wetland is located relatively high on the lower hillside under the BPA powerlines. This area receives drainage from two wooded ravines and is dominated by monotypic stands of reed canarygrass (*Phalaris arundinacea*) and blackberry (*Rubus*). The area drains off downslope through a ditch which then drains under the road to Salmon Creek.

A small, isolated depressional wetland is located on a terrace remnant east of the south part of Mill Creek. This area is close to the steep valley side bluff delimiting the eastern campus area and probably represents an old scour pocket or channel remnant. The area stays wet well into the summer and supports a weedy mixture of reed canarygrass, barnyard grass (*Echinochloa crusgalli*) and knotweed.

Further to the east, a narrow sliver of wetland is found below and between steep valley-side bluffs and the property boundary on the Salmon Creek floodplain. This is at the easternmost end of the site. This area is vegetated with a mixture of emergent and scrub-shrub wetland dominated by species such as cattails and willows (*Salix*) in the wettest areas and by reed canarygrass in drier locations.

**Mill Creek Corridor.** The second major area with wetland plant communities is along the Mill Creek corridor, primarily on and just above the floodplain. Valley-side seepage and concentrated groundwater flow at the mouths of tributary drainageways appear to support most of the more luxuriant wetland vegetation in this area.

Wetland vegetation along the floor of the Mill Creek corridor is dominated by red alder (*Alnus rubra*) and western red cedar (*Thuja plicata*) in the overstory. Understory trees and shrubs include willows, vine maple (*Acer circinatum*), ninebark (*Physocarpus capitatus*), red-osier dogwood (*Cornus stolonifera*), elderberry (*Sambucus*) and salmonberry (*Rubus spectabilis*). Field layer vegetation is largely dominated by creeping Charlie, creeping buttercup, piggyback plant (*Tolmeia menziesii*), waterleaf (*Hydrophyllum tenuipes*), bleeding heart (*Dicentra formosa*), candyflower (*Montia sibirica*), stinging nettle, and touch-me-not (*Impatiens*). Reed canarygrass dominates in sunnier locations, especially just upstream of the farm road crossing.

Seepage zones, perpetually wet locations at the mouths of tributary ravines, and depressions within the bottomland are dominated by very wet plant associations typified by plants such as skunk cabbage, water parsley, American speedwell (*Veronica americana*), bulrush, lady fern (*Athyrium filix-femina*) and wet grasses such as *Glyceria*.

Not all of the bottomland along Mill Creek is wetland. Substantial areas of better drained alluvium are interspersed with hydric soils, creating a mosaic of microsite conditions. Because of site degradation, however, this microsite variability is often poorly reflected in the vegetation in the bottomland. Despite this loss of diversity, the wooded wetlands along Mill Creek are classified as Category 2 wetlands because they are associated with a stream possessing demonstrated spawning habitat for anadromous fish (salmon and steelhead).



**Tributary Drainageways.** All of the wooded draws and ravines draining to Mill Creek or the Salmon Creek terrace surfaces are coursed by small channels supporting year-round flow. These channels are generally incised in silt deposits and locally broaden out in lower gradient portions of the stream profile. Many of these streamside benches, formed relatively recently as a result of slope erosion in the farmed areas, are now wetlands. A number of minor seeps, often emanating from small pan-shaped hollows, also occur along lower ravine sideslopes just above the channels. These and the silt accumulations at valley steps cause the area of wetland along ravine floors to be as much as 30 to 40 feet wide in places. On the other hand, steeper channel segments are only a few feet wide and are bordered by steep upland slopes. These areas often retain gravel/cobble beds since waterborne silt is flushed through these locations.

Vegetation is generally similar along all of the minor streams and associated narrow wetland fringes within the forested ravines. Typical herbaceous elements include wood sorrel (*Oxalis oregana*), creeping buttercup, piggyback plant, lady fern, stinging nettle and occasional skunk cabbage. Where shrub and understory tree elements are present they generally include Indian plum (*Oemleria cerasiformis*), salmonberry, vine maple and elderberries. Red alder and western red cedar are occasionally found rooted in these narrow valley floor wet zones.

All of these small watercourses and associated wetlands are waters of the United States. These areas would be classified as Category 3 wetlands under Clark County's ordinance because they are year-round streams not supporting a salmonid fishery.

**Upper Hillside Wetlands.** The two small patches of isolated wetland identified on the upper bench adjacent to NE 29th Avenue represent seasonally wet areas which largely dry up during the summertime. Wet soil conditions develop over a clay-rich subsoil which perches water during the rainy season. The fields surrounding these small wet pockets were at least intermittently used to grow crops before 1985 but have since been used to produce hay. No areas of Prior Converted Cropland, which are agriculturally-modified wetlands exempt from Corps jurisdiction (Corps 1990), occur on this site.

Because these wetlands have been heavily impacted by agriculture they are dominated by mainly non-native and cosmopolitan grasses and weedy forbs such as bentgrass, reed canarygrass, velvetgrass, slender rush (*Juncus tenuis*), soft rush, and docks (*Rumex* spp.). Although still exhibiting a prevalence of wetland vegetation, nonwetland grasses and weeds are locally common within these areas. Surrounding upland hayfield and pasture communities are dominated by tall fescue, orchardgrass (*Dactylis glomerata*), bentgrass, white clover (*Trifolium repens*), thistle and dandelion, all of which (with the exception of bentgrass) are facultative upland species (Reed 1988). These two wetlands would be classified as Category 4 wetlands under the Clark County ordinance. However, each wetland is under 10,000 square feet in area and is therefore exempted from the provisions of the ordinance.

Two small drainageways traverse the upper part of the property from west to east, eventually draining into the two principal forested ravines in the south part of the site. These swales, which carry only seasonal runoff, have been channelized as part of farming operations. If not deemed artificial wetlands, the two ditches would be classified as Category 4 wetlands because they represent intermittent watercourses not utilized by salmonids.

A number of very small, intermittent seeps (a few hundred square feet in size) are also scattered around the upper bench. These were typically dominated by upland vegetation, generally lacked hydric soils and/or were too small to delineate as discrete wetland areas.

The only area with a prevalence of obligate wetland plants in the upper part of the property was a small patch of cattails located about midway along the western property boundary at NE 30th Avenue. This small seep contributes to flow in the northernmost ditch traversing the upper bench.

There is a broad zone of at least intermittent seepage over the face of the slope (below the uppermost bench) between the two channelized drainages which cross the upper site. This area does not appear to be sufficiently wet to qualify as jurisdictional wetland. A diagonal interceptor ditch has helped to dry this area out and apart from a few stands of reed canarygrass (and some soft rush in the narrow ditch itself), it is dominated by mainly upland vegetation.



## IMPACTS

Direct impacts to wetlands on the WSU Branch Campus property will be mainly confined to elimination of the small, isolated wetland areas located in the southwest portion of the site adjacent to NE 29th Avenue. These areas are already in a heavily degraded condition. The areas will be filled under the provisions of a Corps Nationwide 26 fill permit, which permits the filling of small areas of wetland in locations which are above headwaters and/or isolated from other waters of the United States. These fills, which will total less than one-quarter acre, will require mitigation for their elimination. The small seepage zone (marked by some cattails) along NE 30th Avenue and the two ditches draining eastward across the upper site will also be eliminated (piped).

An access road is planned which would extend from Salmon Creek Avenue north and upslope into the main campus site. The lower part of this road will directly cross the degraded (Category 4) emergent wetlands on the Salmon Creek terrace in the southernmost part of the property. Mitigation will be required for filling these areas.

Grade and traffic circulation considerations require the routing of this road across the two southernmost forested ravines on the site. The narrow ribbon of stream and associated wetland along the bottom of these drainageways will be bridged, although construction of these structures could at least temporarily impact these areas.

Formal pedestrian/bicycle paths will cross wetlands or minor streams at few locations on the lower campus. Mill Creek will also be crossed by a bridge accommodating a path. Construction of these paths will cause the temporary disturbance of wetlands at crossing locations. Wet soils are especially sensitive to disturbance.

**Potential for Dewatering.** By preventing infiltration, the creation of impervious surfaces such as roofs, roads and parking lots within developed areas of the upper site will greatly reduce groundwater recharge in this area (Winter 1988, Ferguson 1990). "Traditional" stormwater management in development sites provides for

the routing of storm runoff from impervious surfaces to pipes and then to detention basins, there to be metered out to existing natural channels. Indirect but potentially substantial impacts to on-site wetlands are likely to be associated with this form of stormwater management because it includes no provision for maintaining the groundwater recharge which supports many of the wetlands on this site.

Reduced recharge is likely to at least partially dewater the minor watercourses in the ravines as well as the lower hillside/terrace wetlands below the main campus development area. The baseflow groundwater component required for summertime streamflow and wetland hydrology support is likely to be particularly affected (Dunne and Leopold 1978, Ferguson 1990 and 1991; B.K. Ferguson, pers. comm., August 4, 1992). Thus watercourses and lower hillside wetlands which now remain wet throughout the summer may become seasonally dry, greatly changing their character.

Additional impacts are likely to occur through the discharge of stormwater to natural channels, whether this occurs as a metered release from detention basins or not. Vegetation removal, soil compaction by heavy machinery, the creation of impervious surfaces, and stormwater piping all typically increase the rate and volume of storm runoff from built areas. Stormwater detention, designed to delay and reduce the peak flow from developed sites, may still permit higher than usual flows in these channels unless the detention basins are unusually large. The discharge from detention basins is low in sediment content because of the stilling effect of the basin and therefore possesses somewhat higher erosion potential than normal flows. Because of these effects, stream channel erosion and enlargement, accompanied by downstream sedimentation, is common in most development areas (Ferguson 1990, Booth 1989 and 1990).

## **MITIGATION**

Direct impacts to all but a few of the wetland areas on the WSU Branch Campus site were avoided by confining the built parts of the campus to the upland areas, mainly on the west side of the property. Only a few small degraded wetlands will be altered and these losses will be mitigated by improving wetland conditions (in



terms of both areal coverage and functions and values) in areas of reserved open space near Salmon Creek Avenue.

There are ample opportunities in the lower portion of the site above Salmon Creek to mitigate for these necessary wetland fills. Mitigation in this area can occur by direct wetland creation, restoration and enhancement (through practices such as planting, the importation of dead woody debris, etc.). The creation/restoration potential of lower site areas is high assuming groundwater supplies from upslope areas can be maintained. The University intends to coordinate mitigation/habitat enhancement efforts in designated open space set-asides with local schools and neighborhood groups. Environmental restoration areas will also be used for demonstration purposes by teachers.

The reservation of a large portion of the property as "natural" habitat, in addition to the planned active restoration of certain wetland, riparian and upland vegetative communities, could facilitate the reintroduction of now scarce plant species into this area. Reserved areas could thus serve as protected sites for a number of the now rare species which otherwise might inhabit all these environments (WDNR 1990).

The old dairy complex along Salmon Creek Avenue will be demolished and all accumulated farm waste will be removed from this location. Wetland is to be restored in this area and this will continue to be fed by drainage from wetlands on the upper terrace west of the barn. This wetland can provide a final water "polishing" function, helping to improve the quality of surface water emanating from the site and discharging to Salmon Creek, which is a water quality limited stream.

Buffers would technically be "required" for most of the wetlands onsite, although in nearly all cases formal buffers will not be applied since these wetlands and their surroundings are to be preserved as open space. Most of the emergent wetlands on the property are Category 4 wetlands requiring a 50-foot base buffer width. The wooded wetlands along Mill Creek, classified as Category 2 wetlands, would require a 200-foot base buffer width but this distance is entirely contained within the area to be reserved as open space. The minor streams and their associated narrow wetland fringes within the forested draws, which are classified

as Category 3 wetlands, would require a 100-foot base buffer width. These areas will also be similarly buffered by even larger areas of reserved habitat.

Elimination of agricultural impacts represents a positive benefit associated with development of the WSU campus. The removal of horses, off-road vehicle traffic and unrestrained pedestrian access to the Mill Creek corridor will also eliminate these direct impacts to Mill Creek and its associated wetlands and tributary watercourses. The many informal footpaths criss-crossing this area will be replaced by a planned path which will avoid wetlands for the most part.

Two of the watercourses within the forested drainageways south of Mill Creek are to be crossed by roads. Bridges are to be used for these crossings, thereby minimizing direct impacts. Planned trails or hard-surfaced pedestrian/bicycle paths will avoid wetlands and watercourses for the most part. Signage and other design provisions will also be used to discourage off-trail travel into sensitive wetland areas. Necessary crossings of wetlands or streams will be by boardwalks or bridges, respectively.

The importance of Mill Creek flow to the maintenance of valley floor wetlands has probably been diminished by channel changes associated with watershed degradation such as channel widening and the loss of in-channel large woody debris. These changes, which have reduced the quality of wetlands in the bottomland (Petts 1990, Gregory et al. 1991), afford excellent mitigation projects for wetland restoration at the site.

**Maintenance of Recharge.** The principal form of mitigation required to sustain wetland functions and values on the WSU Branch Campus site is the maintenance of infiltration and local groundwater recharge. To accomplish this, site stormwater management should emphasize recharge rather than piped flow and detention (Booth 1990, Ferguson 1990 and 1991). Both geotechnical observations and more general observations concerning the hydrologic behavior of forested areas in this and other temperate regions indicate that soils in the portion of the site slated for development are appropriate for recharge.

Promoting local recharge means that runoff from impervious, built surfaces such as roofs, parking lots and roads should be discharged to the ground wherever

possible, although some form of pre-treatment may be advisable in certain cases (e.g. from parking lots). Roofwater is relatively free from most urban contaminants and should be used for recharge purposes wherever possible. Although sloping lawns generally make poor recharge surfaces, many other landscaped surfaces can be designed to accept stormwater while maintaining their infiltration capacity. Naturalistically landscaped areas which mimic native woody plant communities are particularly appropriate for this purpose. Small infiltration basins, swales, beds and other discharge sites, capable of handling surface runoff from adjoining areas, could be employed at a number of locations around the developed part of the campus (Ferguson 1990 and 1991). Undeveloped upland locations between the main campus area and reserved areas downslope should be particularly suitable for use as infiltration areas since they can likewise serve as buffers to sensitive natural areas.

Recharge has an additional aesthetic benefit over the use of stormwater detention basins. Wet basins capable of maintaining luxuriant vegetation are extremely hard to maintain in our seasonally dry climate, particularly in an upland setting. The dry detention basins which would be used in lieu of these have rapidly fluctuating water surface elevations which are not conducive to the establishment of anything but weeds. Such basins tend to become unsightly "weedy holes" during the long, dry summer season.

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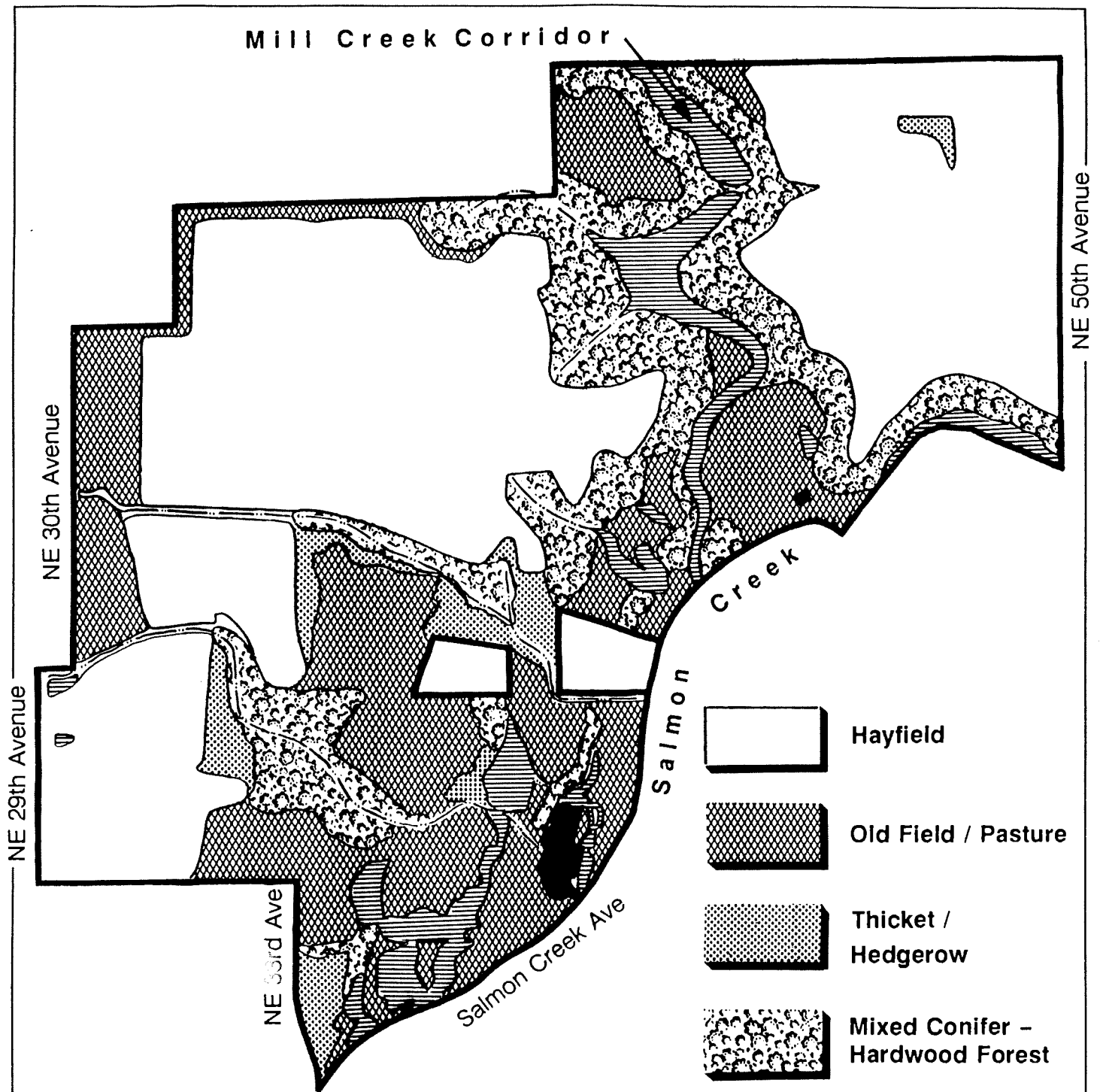
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Source: Aerial photography from WAC Corporation, Eugene, Oregon.  
(flight date June 9, 1991)

## VEGETATION / HABITAT TYPES

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*Supplemental Environmental Impact Statement for*  
**WASHINGTON STATE UNIVERSITY**  
Vancouver Campus



North

Scale 0 200 400 Figure

## **WILDLIFE**

### **EXISTING ENVIRONMENT**

#### **Methods**

Site investigations by the wildlife biologist to identify existing habitat areas on the WSU campus site and document wildlife use of the area were conducted on March 11 and 24, 1992. The first site investigation included a walking survey of the area in which all habitat types were visited. Dominant vegetation, vegetative structure, drainage features, disturbances, and wildlife (and their sign) were observed and recorded. The second site visit was with county and State wetland, wildlife and fisheries staff. Existing site conditions, the scope of the proposed project and its potential resource impacts, and possible mitigative measures were discussed during this tour of portions of the property. Additional observations of vegetation communities, habitat conditions and wildlife, made later in the season by JD White Company environmental staff, are incorporated into this discussion.

This evaluation of existing habitat conditions on the WSU Branch Campus site is consistent with the Natural Areas Inventory technique developed for the Metropolitan Service District (Poracsky 1990). (The METRO inventory and accompanying mapping encompasses much of Clark County.) Additional information pertinent to this report included the site's status with respect to Natural Areas Inventory mapping and the results of a Washington Department of Wildlife nongame wildlife database review.

#### **Habitats**

The principal existing vegetation communities on the WSU Campus site constitute the main different wildlife habitats present in this location. Common elements in the flora of this site are listed in Appendix A. Vegetation provides food and cover, which together with water and space for territory, constitutes habitat. Topography contributes to habitat diversity by providing a range of microclimates (with differences in slope aspect and position), site drainage and soil conditions. These factors in turn cause site-specific variations in the vegetation communities which develop onsite. Site topography is described elsewhere in this document.

The subject property in its entirety represents a rural farm habitat type which is still relatively common in Clark County. This consists of pastures and hayfields interrupted by wooded draws and ravines. All of the site was originally logged and most of it has continued to be grazed or hayed up until quite recently. Second growth forest occupies the several steep draws which penetrate the rolling uplands comprising the bulk of the property. The Mill Creek corridor is also heavily forested. Late summer observations indicate that most of the minor streams within the tributary draws are perennial or nearly so. Degraded emergent wetlands (some exhibiting only seasonal wetness) are located primarily in the midst of open field habitat, mostly on the terraces above Salmon Creek.

Five relatively distinct vegetation/habitat types can be distinguished on this property. These are 1) hayfield, 2) old field/pasture, 3) thicket/hedgerow, 4) mixed conifer-hardwood forest, and 5) the riparian woodland along Mill Creek corridor (Figure 1).

Hayfields and old field/pasture areas collectively constitute the field habitat type. Identified hayfields were cut as recently as 1991 and constitute about half of the entire WSU Campus property. All of the hayfields are in the upper (higher elevation) parts of the site. Old field/pasture areas have not been mowed or cultivated for some years and have generally been invaded by weedy herbaceous vegetation.

Much of the wetland on the property is indistinguishable from the pasture habitat within which it is embedded. These seasonally wet areas are colonized by pasture plants and completely dry up during the summer months. A few seepage wetlands along the back part of the Salmon Creek terrace and adjoining lower hillslope remain wet at the surface throughout the summer and are colonized native and naturalized herbaceous wetland plants. Approximately three-quarters of the 348-acre site consists of the hayfield and old field/pasture cover types (Figure 1).

The remaining one-quarter or so of the WSU Campus site is presently colonized by woody vegetation in different states of succession. This includes larger patches of mixed conifer-hardwood forest, smaller patches of native trees (woodlots), riparian woodland on and adjacent to the Mill Creek floodplain, scattered areas of thickets, and a few areas of hedgerow (hedgerows are narrow corridors of woody vegetation). The thicket/hedgerow habitat type provides much of the most wildlife-useful edge habitat on the property.

**Hayfields.** Hayfields are dominated by non-native introduced grasses such as quackgrass, orchardgrass, velvetgrass, sweet vernal grass, tall fescue and other species. Seeded forbs such as red and white clover and weedy forbs which have invaded these fields (such as thistle and plantain) are intermixed with the grasses.

Hayfields provide nesting cover and seed and green parts for a number of birds (such as sparrows and goldfinches) in addition to small mammals such as rabbits, voles, deer mice and moles. These species in turn serve as prey for raptors such as red-tailed hawks and kestrels. Birds such as robins, barn swallows, yellowthroats and starlings find easy foraging for insects in these fields soon after they are cut.

**Old Field/Pastures.** These are formerly grazed fields of grasses and legumes which have been much more extensively invaded by weedy forbs such as thistle, dandelion, vetch and dock (to name only a few such weeds) than the more intensively managed hayfields. Fringing areas are frequently colonized by invasive Himalayan blackberry thickets. Pasture sites provide similar habitat opportunities as hayfields, although there is a greater diversity of food sources because of the greater abundance and diversity of weed species in these locations.

**Emergent Wetlands.** Several seasonal wetland (wet pasture) areas are found within upland pasture areas in the lower part of the site near Salmon Creek. In addition, a few small patches of such weedy wetland habitat occur in the upper part of the site within or adjacent



to hayfields. These latter areas have been heavily impacted by mowing and disturbances associated with adjacent higher density urban development.

Emergent wetland areas support a somewhat different mix of herbaceous plant species (such as sedges and rushes) than nonwetland field areas. While this adds to the overall plant (habitat) diversity in the immediate area, historic disturbances such as grazing and mowing have caused a prevalence of weedy wetland vegetation such as reed canarygrass and soft rush, which have little wildlife value. Ongoing human disturbances further limits the habitat value of the small wetlands adjacent to 29th Avenue, which are easily accessed by neighborhood children. Although all wetlands can provide amphibian habitat, use other than by Pacific treefrogs will be limited in these areas because of their isolation and/or absence of woody vegetative cover, groundlayer litter and dead/down large woody debris.

**Thicket/Hedgerow Areas.** Brushy areas on the property are typically dominated by early seral native and naturalized woody plants such as blackberry, snowberry, Oregon grape, rose, Scotch broom, young bigleaf maple, hawthorn and other similar species. Shrub in such areas are typically interspersed with openings dominated by bracken, rough grasses and aggressive herbaceous weeds. This type of microhabitat interspersed is valuable for many species of wildlife.

Thickets are located in various locations scattered around the site, notably along woodland edges and within the Bonneville Power Administration (BPA) powerline right-of-way, where vegetation is presumably maintained in an early seral condition by cutting or herbicide treatment. This habitat type also includes areas of ornamental and fruit-producing woody plants (e.g. juniper, cedar, apple, plum, etc.) in the vicinity of former farm buildings and old nursery sites which have become overgrown with disuse.

Much of the most valuable edge habitat on this site occurs in the broad, brushy zones between larger areas of habitat, such as between open fields and woodlands (Figure 1). Such dense, nearly impenetrable thickets provide a wide, "feathered" edge which provides superior habitat to a more abrupt transition between field and forest (Ranney et al. 1981, Reese and Ratti 1988). These areas provide nesting, hiding and resting cover, as well as food, for a wide variety of wildlife species, particularly birds.

Hedgerow habitat is also present on the site. Hedgerows are narrow, linear habitat areas that generally occur along field boundaries and along some of the ditches traversing the upper, western part of the property. Hedgerows are important for many species of wildlife because they not only provide the habitat elements common to other brushy areas but also act as travel corridors between larger habitat patches.

**Mixed Conifer-Hardwood Forest.** The patches and corridors of this habitat type are significant because such woodlands are increasingly being eliminated along the urban fringe in Clark County and these areas support a variety of native plants which historically formed the prevailing habitat type in this region. The fact that on this site each of these woodland patches contains a perennial water source makes them especially valuable as habitat areas for indigenous wildlife populations.

Wooded areas on the property consist mostly of older, even-aged second growth forest stands. Many trees (both conifers and hardwoods) are greater than 24 inches in diameter breast height (dbh). A number of Douglas-firs are as much as 36 inches dbh. The predominant overstory canopy species are Douglas-fir and bigleaf maple in the upper, drier portions of the ravines and western red cedar and red alder in lower, wetter locations within these drainages. Forest canopies are mostly closed with only scattered openings. Snags (standing dead trees) and large downed logs, important wildlife microhabitat elements where they occur, are relatively rare throughout the project site.

The subcanopy and shrub layers in forested areas are dominated by species such as hazelnut, Indian plum, elderberry, vine maple, Oregon grape, snowberry, salal and huckleberry. The floors of forested draws provide moist to wet conditions conducive to the growth of ninebark, salmonberry and young western red cedar.

Shrub layer vegetation abundance is quite variable depending on tree canopy closure and past grazing impacts. Shrub growth tends to be dense along forest edges and in areas where the canopy is more open. Shrubs are much less abundant or almost wholly absent from forested areas which have recently been subjected to heavy grazing. For example, the lower part of the southernmost forested draw on the property has been heavily grazed and as a consequence has very little shrubbery or forest floor vegetation. In contrast, the fenced-off middle part of this drainageway has a lush understory which provides far more wildlife habitat value than the grazed area.

The characteristics of the herbaceous layer within forested areas is again dependent on canopy closure, soil moisture and recent grazing history. The herb layer tends to be most dense in ungrazed areas, near the floors of the forested draws, and in locations where the canopy is more open. Common herbaceous elements in upland forested areas include swordfern, waterleaf, wood sorrel, candyflower, a number of saxifrages, trillium, violet and bleeding heart among other species.

**Forested Wetlands.** Most of the minor drainages with forest habitat are coursed by very small but perennial apparently drainage channels. These streams and the small depositional benches scattered along them form narrow wetland zones which add habitat diversity to the forest patches. Such narrow wetland corridors are typically colonized by wood sorrel, creeping buttercup, piggyback, stinging nettle, sedges, lady fern and occasional skunk cabbage. Most of the skunk cabbage plants are small as these areas are only now recovering from past grazing impacts. Associated woody vegetation includes salmonberry, western red cedar and vine maple.

**Riparian Woodland.** While there is no single definition for riparian zones, these are generally defined as the linear corridors, exhibiting a distinct zonation of vegetation, along larger streams and rivers. Wooded riparian corridors tend to be among the most wildlife-rich locations in the landscape (Brown 1985, Gregory et al. 1991). Riparian woodlands typically encompass a diverse mosaic of vegetation types in various states of succession. This habitat diversity in combination with all necessary habitat elements tends to promote faunal diversity.

The upper riparian (nonwetland) woodland occupying the hillslopes along the Mill creek corridor is dominated by overstory elements such as Douglas-fir, bigleaf maple, western hemlock and western red cedar. Understory trees and shrubs include Indian plum, hazelbrush, vine maple, Oregon grape and elderberry. Groundcover species are similar to those in other moist woodland sites on the property.

The lower riparian zone (floodplain) portion of the Mill Creek corridor consists largely of an overstory canopy of mature red alder although a few western red cedar are also found here. Shrubs and small trees include willows, salmonberry, ninebark, vine maple and red-osier dogwood. Much although not all of this area is wetland. Understory ground layer vegetation is dominated by creeping Charlie, creeping buttercup (both widely naturalized weeds) and piggyback plant; reed canarygrass dominates in the few sunnier openings. Occasional very wet spots on and along the floodplain support skunk cabbage, water parsley, stinging nettle and American speedwell.

As with most other forested areas of the property, dead/down large woody debris and snags are scarce on the floodplain and within the wooded corridor generally. Reflecting recent heavy grazing, forest floor litter is also deficient in most places. The area is extensively trailed and continues to be heavily used by pedestrians, horses and off-road vehicles. A number of bare areas exhibit evidence of significant erosion. Because of this disturbance history as well as the generally open understory and paucity of ground-level woody debris within the corridor, this area provides much poorer habitat conditions than it would otherwise. Species affected by this scarcity of dead/down wood and litter, in particular, include many species of invertebrates, terrestrial salamanders and small mammals.

### **Wildlife Observations**

Twenty-eight species of birds, eight mammal species, one reptile and two amphibian species were observed and noted during site visits between March and August, 1992 (Table 1). Most of the mammal species were evident from their sign. The list of observed species in Table 1 is not a complete account of the wildlife that likely utilizes the project site. More secretive species such as nocturnal animals, small fossorial mammals, and many reptiles and amphibians are not readily detected without a much more extensive field investigation. Other species, particularly birds, may use site only for relatively brief periods during migrations. Still other birds are summer or winter residents of the habitat types present on the property.

The relatively large variety of wildlife species that utilize rural forest, field, hedgerow and wetland habitats in this region could be expected to occur on this site. Unpublished field data (Porascky et al. in press) and information from regional listings (e.g. Guenther and Kucera 1978, Brown 1985) provide additional information on some of the wildlife species likely to at least seasonally inhabit this area. Some of these species are listed by generalized habitat area in Appendix B. All of the species listed do not necessarily occur here and many other species which are not listed undoubtedly do inhabit the area. The listing is only intended to supplement the list of observed species and generally characterize the fauna associated with the major, distinct vegetation/habitat areas on the property.

Table 1.  
Wildlife species observed on the WSU Branch Campus site  
Vancouver, Washington, March-August 1992.

## Birds

Red-tailed Hawk (*Buteo jamaicensis*)  
American Kestrel (*Falco sparverius*)  
Dark-eyed Junco (*Junco hyemalis*)  
Golden-crowned Kinglet (*Regulus satrapa*)  
Barn Swallow (*Hirundo rustica*)  
Scrub Jay (*Aphelocoma coerulescens*)  
Steller's Jay (*Cyanocitta stelleri*)  
American Crow (*Corvus brachyrhynchos*)  
Violet-green Swallow (*Tachycineta thalassina*)  
Bewick's Wren (*Thryomanes bewickii*)  
Winter Wren (*Troglodytes troglodytes*)  
House Finch (*Carpodacus mexicanus*)  
American Robin (*Turdus migratorius*)  
American Dipper (*Cinclus mexicanus*)  
Common Yellowthroat (*Geothlypis trichas*)  
Song Sparrow (*Melospiza melodia*)  
Lazuli Bunting (*Passerina amoena*)  
Black-capped Chickadee (*Parus atricapillus*)  
Bushtit (*Psaltirparus minimus*)  
Rufous-sided Towhee (*Pipilo erythrophthalmus*)  
Red-breasted Nuthatch (*Sitta canadensis*)  
Downy Woodpecker (*Picoides pubescens*)  
Northern Flicker (*Colaptes auratus*)  
Pileated Woodpecker (*Dryocopus pileatus*)  
European Starling (*Sturnus vulgaris*)  
Rock Dove (*Columba livia*)  
Killdeer (*Charadrius vociferus*)  
Mallard (*Anas platyrhynchos*)

## Mammals

Virginia Opossum (*Didelphis virginiana*)  
Eastern Cottontail (*Sylvilagus floridanus*)  
Beaver (*Castor canadensis*)  
Gray Squirrel (*Sciurus carolinensis*)  
Mole (*Scapanus* sp.)  
Coyote (*Canis latrans*)  
Raccoon (*Procyon lotor*)  
Black-tailed Deer (*Odocoileus hemionus*)

## **Amphibians**

Pacific Treefrog (*Hyla regilla*)  
Bullfrog (*Rana catesbeiana*)

## **Reptiles**

Garter Snake (*Thamnophis* spp.)

## **Rare, Threatened and Endangered Species**

A Washington Department of Wildlife Natural Heritage Data System review for records of sensitive, threatened or endangered (STE) nongame wildlife species was conducted on this site. No such special animal species have been noted and recorded for the project area (see Appendix C). The Washington Department of Wildlife's District Biologist was contacted but he is not aware of any STE wildlife species on the site (Carl Dugger, pers. comm., March 24, 1992). No federal- or state-listed STE wildlife species were observed onsite during field investigations.

Staff of The JD White Company did observe an immature bald eagle during the first week of March 1992 approximately one-quarter mile north of the site along the BPA right-of-way. Given the time of year and the fact that preferred bald eagle habitat does not exist on this site, this eagle was likely a migrant passing through the area. The bald eagle (*Haliaeetus leucocephalus*) is a threatened species in Washington and is also federally listed (Washington Department of Wildlife 1991a).

Pileated woodpeckers have been observed twice on the WSU site during the spring of 1991. The pileated woodpecker (*Dryocopus pileatus*) is a state Candidate species for possible future listing as sensitive or threatened (Washington Department of Wildlife 1991a). Pileated woodpeckers inhabit older conifer forests almost exclusively, preferring multi-layered stands greater than 70 years in age, particularly those with abundant large snags for nesting, roosting and foraging (Washington Department of Wildlife 1991b). The preservation and continued maturation of the conifer-dominated forest stands on the WSU site should locally benefit this species.

State-listed Monitor wildlife species are of special interest for a number of possible reasons but are not considered in danger of extirpation (Washington Department of Wildlife 1991a). A number of monitor species may occur on or visit this site. These include the Pacific gopher snake, great blue heron, turkey vulture, several species of small rodents and bats, and a number of species of butterflies.

The WSU campus site is unlikely to support STE or Candidate wildlife species otherwise capable of potentially occurring in this region because of extensive historic land use impacts to the site specifically and to the regional landscape generally. Onsite impacts include a long history of agricultural use which has significantly degraded all available habitat areas. Much of the

site has been converted to intensively managed fields while other fields have been grazed up until quite recently. Even areas retaining semi-wild vegetation have been degraded by logging and log salvage (leaving few snags and little dead/down woody debris), grazing, and slope erosion. Channel sedimentation from erosion in upgradient fields has impacted all of the drainages penetrating the site. Continuing human disturbance, particularly along the Mill Creek corridor, would also tend to exclude most especially sensitive STE or Candidate species from this area.

### **Landscape Setting and Site Wildlife**

Landscape-scale factors have significantly influenced both resident and transient wildlife populations currently utilizing the WSU Campus site. Natural Areas Inventory mapping shows that the project area contains sizeable areas of forest habitat in close proximity to the largely developed urban core (Figure 2). The Mill Creek corridor and contiguous forested slopes, both on and offsite, represents one of the larger habitat patches in this region. This area of upland forest and wooded stream corridor is about one square mile in size and is linked by the narrow wooded zone along the southernmost reach of Mill Creek to the wooded (but partly built) Salmon Creek corridor.

The development of roads, logging, and agricultural land conversion originally fragmented the pre-European coniferous forest habitat which formerly covered this area. However, the fact that the WSU Campus site remains adjacent to mostly rural and low-density residential areas (mainly to the north and east) which retain extensive areas of open space and scattered patches of forest accounts for the continued presence of larger mammals such as deer and coyotes on the site. These and other relatively secretive species may ultimately vacate this area as urbanization and its accompanying disturbance and habitat fragmentation continues in this part of Clark County. On the other hand, maintenance of habitat patches and linked wildlife travel corridors of native vegetation between these patches can help to counteract this effect (Noss 1987, Lehmkuhl and Ruggiero 1991, Soulé 1991).

Although a substantial area of natural habitat remains on and around the WSU Campus site, the encroachment of agricultural fields on forested ravines has sufficiently narrowed the forested areas to the point that no true forest interior habitat currently remains on the site. Edge-related effects extend many hundreds of feet into forested areas (Reese and Ratti 1988, Lehmkuhl and Ruggiero 1991). No area of uninterrupted forest habitat on the project site is wide enough to avoid these effects.

A number of animals in our region tend to dwell almost exclusively in large blocks of forest interior habitat and tend to avoid habitat edges. Examples include some of the mammalian predators (e.g. marten), several species of bats and voles, and many species of birds (e.g. varied thrush, Wilson's warbler, brown creeper, western flycatcher, golden crowned kinglet). These predominantly forest-dwelling species are becoming increasingly scarce in this region as forest patches become more and more fragmented and reduced in size. The proliferation of edges with habitat fragmentation can be deleterious to forest-interior species because of exposure to the elements, competitive exclusion by opportunistic edge-adapted species, nest predation (e.g. by crows, jays, skunks and opossums), and brood parasitism by cowbirds (Reese and Ratti 1988, Lehmkuhl and Ruggiero 1991).

As a consequence of the regional increase in edge habitat and breakup of larger forest stands in this area, both native and introduced edge-dwelling species currently dominate the vertebrate fauna of the WSU Campus site. Typical bird species inhabiting edges (and among the species most frequently seen here) include jays, crows, yellowthroats, towhees, robins, starlings, finches and song sparrows.

## **IMPACTS**

Adverse impacts to wildlife associated with the development of the WSU Campus site will primarily be in the form of disturbance and displacement, loss of habitat areas, and direct mortality due to site clearance and increased vehicle use in the area. Although most campus infrastructure will be confined to the upper part of the site, human disturbances to wildlife will generally increase in the overall area. Disturbance factors include traffic and noise, lights and other visual disturbances, and more frequent human intrusion into remaining habitat areas. Increased human use of the area can be expected to result in the decline of disturbance-intolerant species such as coyotes, raptors and black-tailed deer. In contrast, opportunistic species common to inhabited areas (e.g. robins, crows, jays, starlings, song sparrows, opossums, racoons, etc.) are likely to both persist and prosper.

Increasing use of the area by domesticated dogs and cats is also likely to locally impact wildlife populations. Cats are particularly important predators of birds and unleashed dogs will also harass many forms of wildlife.

Most of the open field habitat on the property will be lost with the development of the campus. The first phase of campus construction will apparently remove all of the field area west of Mill Creek, replacing it with campus building, roads, parking lots and ornamental vegetation. Open fields and their associated weedy edges support a variety of small mammal, song bird and raptor species.

An existing drainage ditch, lined with woody vegetation in addition to weedy grasses and forbs, currently extends east from NE 30th Avenue across existing hayfields to a wooded ravine. This feature provides shrub/hedgerow and tall herbaceous habitat as well as a seasonal water source. This type of area is used by eastern cottontails, yellowthroats and goldfinches, to name only a few species characteristic of such areas. The ditch will be eliminated under the current campus plan.

The wildlife impacts associated with conversion of open field and field edge to landscaped campus areas cannot be completely determined at this point because landscaping details remain unspecified. However, manicured lawns and intensively maintained ornamental planting areas generally offer little value to wildlife. Furthermore, the pesticides and fertilizers used in such areas can be directly toxic to animals. Pesticide treatment also reduces the food supply used by many vertebrate wildlife species.

The campus plan shows an entrance road traversing the hillside and extending generally northward into the site from Salmon Creek Avenue. This road will bisect pasture and seasonal wetland areas, woodlots and two forested draws. High quality forest habitat will be impacted as the road crosses the central part of the southernmost forested ravine. The

central portion of this woodland contains some of the highest quality forest habitat in the area as it has long been fenced off from cattle. As a consequence, this area possesses well-developed forest floor and subcanopy layers and also contains a considerable quantity (for this property) of large dead/down woody debris. While a bridge is planned over the watercourse in this drainageway, the road will still fragment this currently intact patch of maturing mixed coniferous-hardwood forest.

An important wildlife impact would occur if the minor watercourses and seepage wetlands on the property were dewatered by site development. These features provide unique habitat opportunities to wildlife and act as permanent water sources utilized by animals ranging over the entire site or migrating through the area. Perennial water sources are particularly important because of the normal extended summer drought in this region. These water areas also have the potential for becoming increasingly valuable as amphibian habitat as they are allowed to recover from past agricultural abuses. Amphibians as a group are becoming rare on a regional basis and a large part of this decline can be attributed to habitat degradation through the dewatering and siltation of wetlands and watercourses.

The potential for at least partial dewatering exists on this site because of the replacement of open fields receptive to rainfall with building roofs, roads and paved parking areas. Rainfall interception by these impervious surfaces, and conventional stormwater routing to the steep natural channels draining the site, would result in a substantial loss of recharge to local groundwater supplies. This type of stormwater management scheme could result in loss of habitat through both elimination of summertime flow in the ravines and drier conditions in the seepage wetlands located along the lower slopes. Channel incision is also possible along the minor watercourses as extra water is supplied to these areas during storms. Through these mechanisms, the habitat quality of areas which have otherwise been set aside for wildlife and open space conservation could seriously decline because of development in upgradient areas.

## **MITIGATION**

Both overall site planning as well the nature of many site design details can go a long way towards either exacerbating or mitigating wildlife and wildlife habitat losses on a site as large as this. Substantial impacts to the most significant habitat areas on the property were avoided at the outset by confining nearly all of the built part of the campus (buildings, roads and parking lots) to the existing open field areas in the upper parts of the site. Development will occur mainly in the existing hayfield areas and to a somewhat lesser degree in old field/pasture areas. A small amount of thicket/hedgerow habitat will also be lost. "Natural" areas with largely native woody vegetation have been set aside as open space areas. Confining development to a certain area of the property while retaining the remainder of the site as contiguous habitat is one of the best ways to minimize local habitat fragmentation and promote wildlife maintenance (Noss 1987, Soulé 1991).

State and local resource agency biologists were most concerned about preserving the integrity of the Mill Creek corridor as a means of minimizing the wildlife impacts associated with development of the WSU Branch Campus. The forested corridor of Mill Creek is to be wholly preserved. Conservation of the Mill Creek corridor is especially useful because



of its connectivity with both offsite habitat areas and the large area of diverse habitat to be conserved onsite (Noss 1987, Soulé 1991).

Agency personnel also recommended that a bridge replace the existing culverted fill at the old farm road crossing spanning the northern part of Mill Creek on the property. While this initially appears to be a sound recommendation, more careful analysis suggests that removal of the fill crossing would cause substantial degradation of the Mill Creek floodplain and channel downstream of the crossing. The existing fill has long acted as sediment trap which helps to preserve unburied spawning gravels in the downstream reach of Mill Creek. The existing narrow, almost unused road crossing also presently causes minimal disruption to animal movements. Any upgrade of the fill to accommodate a wider, more heavily used road should include an underpass, along the edge of the floodplain above normal flood elevation, to facilitate the safe movement of terrestrial wildlife up and down the Mill Creek corridor. This feature can simultaneously function as a flood bypass.

Setting aside the Mill Creek corridor from any form of development will allow habitat conditions in this area to gradually improve as existing disturbances (e.g. horse, off-road vehicle and unrestricted pedestrian traffic) are eliminated. Locally improved habitat conditions will result from the re-development of canopy and understory vegetation as well as the gradual accumulation of forest floor litter and larger woody debris. Forested slopes which have been overgrazed by cattle will similarly improve. Conservation of the Mill Creek corridor also preserves an important link in the stream/wildlife corridor system within the greater Salmon Creek watershed.

Re-linkage to the Mill Creek corridor of the now partially isolated forested ravines to the immediate south of here will also enhance the connectivity of the wooded habitats in the area. Restoring at least 200-foot wide corridors of tree and shrub species to the existing short gaps between the forested ravines overlooking Salmon Creek and the wooded Mill Creek corridor will greatly expand the area of contiguous forest habitat on the site. Re-linkage can probably best be accomplished along the upper Salmon Creek terrace near the mouths of these ravines as this area has been reserved for conservation purposes.

Not all areas reserved for open space should be planted with woody vegetation (or be allowed to grow back to woody species). It would be desirable to arrest succession and maintain certain areas as fields, either by mowing or periodic burning, as it is mainly this type of habitat that will be impacted by campus development. Portions of the existing fields on terrace surfaces overlooking Salmon Creek Avenue and along the Mill Creek corridor can be maintained in this way. Such fields will provide habitat for invertebrates (including butterflies) and small mammals which serve as prey for many species of birds and mammals. Red-tailed hawks and great horned owls, which nest and roost in the forest, forage for prey in meadow areas.

The road bisecting the central part of the southernmost forested ravine will further fragment one of the highest quality forested areas on the site. Bridging the ravine, as planned, will benefit wildlife and permanently disturb far less of the existing woodland than a fill would. Nevertheless, it would be desirable to avoid the core forested area to the maximum extent possible if grade and geotechnical considerations permit. The lower and uppermost wooded

portions of this ravine are currently in a far more degraded condition than the central area. These areas would therefore serve as better locations for a road crossing from a wildlife maintenance standpoint.

Roads, especially those carrying heavy traffic, should avoid existing and enhanced open space/habitat areas to the maximum extent possible. Even empty roads represent real barriers to many smaller ground-dwelling wildlife species (because of the animal's resistance to expose itself to predators), thereby effectively fragmenting and reducing the useful habitat of these species. Roads also represent a major cause of animal mortality (Noss 1987).

A number of trails or more formal pedestrian/bicycle paths are proposed for otherwise undeveloped portions of this site. The area traversed by trails or paths should be minimized to the maximum extent possible in order to reduce wildlife impacts. Paths should skirt (rather than penetrate) high quality habitat areas to the maximum extent possible and parallel trails should not be placed along both sides of creeks. Stream and wetland crossings should be by bridges or boardwalks, respectively, and should be designed to minimize off-trail traffic. As much of the trail system as possible should be of "primitive" design (narrow, natural surface) and should serve only pedestrians. Trailside signage should educate users about wildlife and its protection.

Paths outside of existing wooded areas can be planted with verges of native woody vegetation in naturalistic patterns (see below) designed to simulate hedgerows or other edge habitats. Paths enhanced in this manner can facilitate animal movements through more open areas. Borders such as this need not be completely continuous to be useful to wildlife.

Extensive orchard-style tree plantings are planned for parking areas. Within the limits imposed by maintenance and other requirements, trees with dense tree crowns (for cover) and trees producing wildlife-useful fruit should be used in parking areas if possible. Using a large variety of tree types with different cover and food-producing characteristics, and intermingling these in the parking areas, would also improve habitat values.

Use of naturalistic landscaping schemes wherever possible on the campus can reduce wildlife impacts (and even improve habitat conditions) in comparison to more formal and traditional landscaping designs. Naturalistic design involves establishing native plants and other habitat elements in patterns which mimic in form and function natural vegetation communities, thereby providing the vegetative and structural diversity at the root of habitat and wildlife diversity. It also utilizes indigenous plant species to which local wildlife are adapted. Plants adapted to local soil and climate conditions do not require the chemical maintenance which can poison wildlife. Naturalistically landscaped areas of woody vegetation which are allowed to accumulate a litter layer also maintain good infiltration characteristics and thus act as local recharge areas.

Buffer zones should be provided between buildings, roads and parking lots and reserved native habitat areas. These zones should be as wide as possible and should be landscaped using naturalistic techniques. All plantings should have food and/or cover value for wildlife, emphasizing the provision of food supplies over as long a period of the year as possible. Some of the native woody species which would be useful in these areas include elderberry,

hazelnut, snowberry, huckleberry, currant, Oregon grape, rose, and a number of evergreens (for thermal and hiding cover). Dead brush, dead/down woody debris and ground litter can be salvaged from construction areas and placed within buffer zones to immediately improve structural habitat conditions and provide shade for young plantings. If desired, somewhat more formally landscaped strips or verges can be used to separate these necessarily "untidy" buffer zones from developed parts of the campus.

Erosion control practices should be diligently applied during construction and the amount of land cleared during construction should be minimized in order to minimize soil erosion and reduce habitat loss. Special care should be taken to prevent sediment from entering the minor drainages on the property, all of which have already been impacted by siltation associated with poor farming practices.

Maximizing the maintenance of groundwater recharge in the built part of the WSU Campus site would have direct implications for wildlife maintenance. Watercourses and wetlands supported by groundwater recharge in upland areas of the site contribute greatly to both existing habitat quality and the habitat restoration potential of this property. Groundwater recharge should therefore be incorporated into the developed site's stormwater management plan to the maximum extent possible.

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## FISHERIES

### EXISTING ENVIRONMENT

The only perennial stream on the Washington State University (WSU) campus site which supports a fishery is Mill Creek. A number of short, steep channeled ravines on the property drain to Mill Creek or Salmon Creek. Although all of these are apparently perennial, they support only a small quantity of surface flow and are for the most part inaccessible to fish. The quantity and quality of water that issues from these minor drainages nonetheless indirectly influences the fishery resource of the Salmon Creek system.

Salmon Creek and its tributaries originally supported substantial populations of anadromous salmonids (salmon and trout species that migrate between salt- and freshwater as a part of their life cycle). Native species apparently included coho salmon (*Oncorhynchus kisutch*), chum salmon (*Oncorhynchus keta*), chinook salmon (*Oncorhynchus tshawytscha*), cutthroat trout (*Oncorhynchus* [or *Salmo*] *clarki*) and steelhead (*Oncorhynchus mykiss* [or *Salmo gairdneri*]). Steelhead is the anadromous form of rainbow trout; cutthroat trout may occur as both resident and sea-run populations. Coho is reported to have formerly occurred in the largest numbers in the basin and this still appears to be the case (Clark County Conservation District 1989, Meehan 1991).

Although salmonid populations are now only a small fraction of what they were historically, coho, steelhead and cutthroat trout still inhabit the Salmon Creek basin in small numbers. Based on redd (nest) counts, the latest survey (1988-89) suggests that at least 112 coho, 98 steelhead and an undetermined but much smaller number of cutthroat spawned in the entire Salmon Creek system during that period. Only 20 live adult fish were observed during these surveys, a tiny number considering that before European settlement this 92-square mile basin must have contained at least several hundred miles of streams that could have been used by fish. Substantial portions of this original channel network have now been piped, ditched, blocked or otherwise rendered useless to fish.

Based on trapping during outmigration in the spring, salmonid production in 1989 was estimated to total 6714 juvenile fish. However, a massive manure spill in the upper portion of the Salmon Creek basin, which resulted in lethal concentrations of ammonia in mainstem Salmon Creek during the period of outmigration, probably greatly reduced actual juvenile populations that year (Clark County Conservation District 1989).

Steelhead and coho redds have been observed on Mill Creek during surveys conducted over the past 20 years but none were observed during the most recent 1988-89 surveys. No fry or smolts were observed on Mill Creek during the 1988-89 habitat inventory of this creek (Clark County Conservation District 1989). (Fry are newly emerged juveniles and smolts are juveniles which are one year or older and are physiologically prepared to migrate seaward.)

All or most of the existing salmonid fishery in the Salmon Creek basin is believed to consist of stocked fish (Clark County Conservation District 1989). Jack salmon (young adults, usually males) can still be taken from July 1 to October 31 in lower Salmon Creek, but the stream and its tributaries above the Interstate 5 bridge is presently closed to salmon fishing in an effort to promote recovery of the fishery. (Most of the salmonid habitat in the basin is above the I-5 bridge. A slough-like, silt-floored channel predominates below this down to the mouth of the creek at Lake River.) Steelhead, cutthroat trout and other fish may be taken during the period June 1 through March 31 from the mouth of Salmon Creek up as far as 72nd Avenue, with fishing off-limits above this point.

A number of fish species other than salmonids are known to inhabit Salmon Creek and its tributaries, including Mill Creek. Among the more common native species are reidside shiner (*Richardsonius balteatus*), several species of sculpin (*Cottus* spp.), northern squawfish (*Ptychocheilus oregonensis*), speckled dace (*Rhinichthys osculus*), longnose dace (*Rhinichthys cataractae*), bridgelip sucker (*Catostomus columbianus*) and three-spine stickleback (*Gasterosteus aculeatus*). A number of other bony fish species as well as Pacific lamprey (*Entosphenus tridentatus*), which is anadromous and parasitic on salmonids, also occur in the basin. Species introduced from the midwestern and eastern U.S. also now inhabit the Salmon Creek system in sizeable numbers. These include catfish such as brown bullhead (*Ictalurus nebulosus*) and sunfishes like bluegill (*Lepomis macrochirus*) and pumpkinseed (*Lepomis gibbosus*) (Clark County Conservation District 1989, Wydoski and Whitney 1979). Many of the introduced species prefer warmer, quieter, more nutrient-rich water than the salmonids and other native species, thriving here because of alterations to the morphologic characteristics as well as hydrologic and temperature regimes of the streams in the basin.

### **Mill Creek Channel Conditions**

The WSU campus property encompasses about 4000 feet of lower Mill Creek, which joins the mainstem Salmon Creek just beyond the property boundary (north of the Salmon Creek Avenue bridge over Mill Creek). Over most of its length on the campus, the stream assumes a highly sinuous or meandering channel pattern. This is etched into a 100- to 300-foot wide floodplain which is bordered by heavily forested, moderate to steep valley sideslopes. After breaking out of this canyon, the lower 500 feet or so of Mill Creek assumes a much more confined and less sinuous course as it crosses the older terrace surfaces bordering Salmon Creek. The active (regularly flooded) channel of lower Mill Creek is as much as 40 feet wide in the tightly meandering portion of its course south of the old farm road crossing which bisects the creek corridor on the WSU property. It becomes substantially narrower in the more confined reach just above the Salmon Creek Avenue bridge.

Much of the stream below the old road crossing retains a gravel and cobble bed, particularly in the somewhat steeper reach just above Salmon Creek Avenue. Fine sediment can evidently be sluiced on through the system here. The gravel/cobble streambed in the meandering reach just above this has a thicker veneer of silt (is more "embedded"). (Embeddedness refers to the extent that the void space between the

gravel- and cobble-sized particles of the streambed are filled with silt and other fine [even organic] material. This greatly reduces or even eliminates the ability of the substrate to support both fish spawning and the aquatic insects which are the food of fish.)

The stream channel above the old road crossing fill, which is pierced by a very large steel culvert, is heavily charged with silt. Most of the gravels and cobbles of the streambed here are completely buried by recent fine sediment deposits. This demonstrates that the road crossing has long been acting as a sediment trap and has captured much of the silt brought down from higher in the watershed.

Mill Creek has an average stream gradient of about 1% (around 53 feet per mile) on the WSU property, which is fairly low. While the creek is perennial through the campus property, it typically dries up during the summer only a few miles north of this area (Clark County Conservation District 1989, USGS 1975). It is possible that during very dry years or during a succession of dry years, late summer flow in this tributary could disappear altogether. It is likely that land use changes in the basin will accelerate this trend.

Unlike much of middle and upper Mill Creek, where all riparian vegetation has been cleared along many segments of the stream, the lower Mill Creek riparian corridor is largely wooded. This is advantageous from a fish habitat standpoint. During the summer, shade provided by the woodland canopy over the stream helps to lower water temperatures otherwise elevated in unshaded areas upstream of the campus site. Lower water temperature promotes higher dissolved oxygen content and salmonids require cool, oxygen-rich water to thrive.

The roots of streamside trees also help to stabilize streambanks in this area, although there remain a large number of eroding cutbanks through this reach. Because most of the trees in the floodplain are fairly young, streambank root systems are in general poorly developed. To the fishery's benefit, many of the eroding streambanks in this area are composed of sand, gravel and cobbles instead of silt.

Vegetation along the wooded riparian corridor traversing the WSU site includes alder, bigleaf maple, Douglas fir, western red cedar, salmonberry, ninebark, and a number of other woody species. Trees are not very old because the area was last logged several decades ago. The only sizeable opening along the creek corridor occurs at the farm road crossing. Much of this open, sunny area is infested with reed canarygrass and blackberries.

### **Stream Impacts and Limiting Factors**

Although bordered by dense vegetation, the reach of Mill Creek flowing through the campus site has nonetheless been severely impacted by both onsite uses and upstream (watershed) activities. Land use impacts have unquestionably changed the physical appearance, water quality, and hydrologic regime of Mill Creek in relation to what they



were formerly. All of these changes have adversely impacted the native coldwater fishery.

**History.** Initial impacts to Mill Creek occurred with the beginning of logging in the basin sometime last century. Logs and root wads (large woody debris) in and along the stream were probably initially lost when this material was salvaged for commercial purposes or was cleared in order to allow the transport of logs released from upstream splash dams (Clark County Conservation District 1989). Additional impacts accompanied conversion of the watershed to agricultural uses. Riparian vegetation clearance for wood and land drainage, as well as livestock access, has resulted in extensive channel bank erosion. Decades of generally poor farming practices have also introduced massive quantities of sediment into the stream system.

Land conversion from forestland to cropland and pastureland has unquestionably altered the hydrologic regime of the creek. Typically, this involves a substantial change in river regime as watershed conditions change from one of recharge and minimal surface runoff (with the forested condition) to one where surface soil infiltration is reduced and overland flow occurs much more frequently from a larger percentage of the terrain. The former river regime is characterized by infrequent bankfull flows which develop only slowly as well as by extended dry season flow, even in small headwater tributaries. The latter regime is much more "flashy" and is characterized by an increased frequency of high flows and reduced summer baseflow (to the point that many streams become entirely dewatered during the dry season). Water quality impacts associated with agriculture also include high stream turbidity (from sediment) and pollution due to fertilizers, pesticides and animal wastes (Dunne and Leopold 1978, Meyers et al 1985, Meehan 1991).

The particular mix of stream impacts associated with urban development have just begun to influence Mill Creek but this influence will unquestionably become more important as the basin builds out. Urban stream impacts from the water quantity standpoint are in many ways similar to those associated with conversion to agriculture, although they are generally much more intense. These changes mainly result from greatly increased surface runoff due to the creation of large areas with impermeable surfaces (roofs and pavement) and efficient stormwater routing to channels through gutters and drainage pipes. Downstream effects include increased frequency of flood flows, reduced dry season flow, and higher flood velocities. Urban water quality impacts include sediment contamination from eroding uplands (especially construction sites), higher stream temperatures, nutrient and bacterial contamination (from fertilizer in runoff, leaking sanitary sewer and septic systems) and the introduction to surface waters of the many toxic compounds associated with urban activities. These include heavy metals, pesticides, detergents and petroleum products (Dunne and Leopold 1978, Schueler 1991).

**Basinwide Problems.** Extensive studies were conducted on Salmon Creek and its tributaries in 1988-89 in an effort to identify the causes of the decline in the salmonid fishery, at least those that could be associated with conditions in the basin itself (Clark County Conservation District 1989). Reflecting more than a century of land use impacts of the type described above, the principal problems besetting the Salmon Creek basin

fishery were identified as 1) burial of many of the spawning beds in the creek system because of severe upland as well as streambank erosion, and 2) a lack of instream habitat, particularly rearing habitat.

Deep, high quality pool habitat, in particular, is especially scarce. Pools serve as important summer nursery areas for juvenile fish, provide cover for adult fish, and act as thermal refuges during summer low water conditions (Meehan 1991). Loss of pools and other manifestations of stream habitat diversity can be attributed to both the absence of instream large woody debris and to siltation. This has caused the pool-riffle complex of the pristine, pre-European stream to be replaced by shallow, featureless "glides" which offer fish little in the way of food, cover, or refuge from floods, drought or predation (Schlosser 1991). Other limiting factors which are suspected of being important throughout the basin include low summer streamflows, high summer water temperatures, and low dissolved oxygen content in summer (Clark County Conservation District 1989).

High water temperatures result from the loss of the shade provided by streamside vegetation but low water conditions exacerbate stream heating. High water temperatures can be directly lethal to fish, can increase fish susceptibility to parasitism and disease, can inhibit the upstream migration of adults, can provide a competitive advantage for warmwater species, and can depress dissolved oxygen levels (Meehan 1991, Schlosser 1991).

**Problems Specific to Mill Creek.** The principal fishery resource problem on the lower five miles of Mill Creek itself has been identified as loss of spawning substrate due to massive siltation. High summer water temperatures and low flow conditions are additional suspected limiting factors on Mill Creek (Clark County Conservation District 1989). Potential spawning habitat is apparently limited to the stream reach below the old road crossing on the campus property and to another area in the vicinity of Dollars Corner, well upstream. Suspected poor water quality in Mill Creek is attributed to leaking septic systems and unrestricted livestock access to the stream in much of the upper part of the basin (Clark County Conservation District 1989).

Sediment continues to reach Mill Creek on the campus site itself because of erosion on adjacent upland and floodplain areas due to heavy off-road vehicle and horse traffic. It is also apparent that there is virtually no large woody debris in the creek or on the floodplain in the campus area. Large logs provide instream cover and pool habitat, retain spawning gravels, and are especially important to stream channel stability (Meehan 1991, Schlosser 1991).

In addition to the impacts of logging, streamside vegetation along lower Mill Creek is only now recovering from historic grazing. The absence of stabilizing riparian vegetation and large woody debris typically results in channel overwidening, especially when this is coupled with the increased frequency of erosive bankfull flows because of watershed degradation. For these reasons, the channel of Mill Creek is far wider (and therefore shallower) than it should be, particularly where it is not confined by its valley. High flows can directly impact fish by physically washing them through the system. The holding cover and protected backwaters provided by dense streamside vegetation and

accumulations of logs and root wads generally prevent this from happening (Meehan 1991).

The large suspended culvert in the farm road crossing forms a barrier to fish passage at times of low to moderate flow. The fact that salmon have been observed upstream of here, however, indicates that it must be passable at certain times (Clark County Conservation District 1989). This culvert should be retrofitted with a fishway to better facilitate safe fish passage during a range of flow conditions or re-designed for this purpose if the road crossing is upgraded in the future.

### **Opportunities for Stream Restoration and Enhancement**

Instream habitat restoration and enhancement measures should be aimed at restoring structural habitat elements, creating rearing habitat, and retaining spawning gravels as part of the larger effort to restore viable fish populations to Mill Creek. A variety of techniques could be applied here. These include the careful placement of instream and streambank structures, constructed of rocks and logs, to create more juvenile rearing habitat, trap spawning gravels, and prevent bank erosion. Typical structures would include low-profile log or rock dams and current deflectors. Structures of this sort mimic in function, and partially replace, the large woody debris now absent from the channel/floodplain system. Other factors being equal, increases in stream channel habitat diversity are reflected in increases in fish population along a given reach of stream (Meehan 1991, Schlosser 1991).

Gravels downstream of the old road crossing could also be cleaned to remove excess fine sediment at the same time that cross-channel dams, wing deflectors or other such devices are installed. Dams or weirs, as low drop structures, both trap gravels upstream of the structure and create a self-scouring plunge pool below the overfall. Clean gravels could also be directly introduced upstream of these structures or above low sills specifically designed to retain gravel in the stream (Clark County Conservation District 1991, Meehan 1991).

Improvement of spawning conditions on the campus portion of Mill Creek would appear to be useful since spawning habitat is limiting basinwide and this is only one of two identified spawning areas on Mill Creek itself. The upper spawning area in the vicinity of Dollars Corner must be much more susceptible to dewatering and continued siltation than the downstream spawning area on the Campus site (Clark County Conservation District 1989). This lower area also has the advantage of having, in the old road crossing, a sediment retention structure which can help to maintain in good condition any habitat improvements made downstream of it. Gravel restoration in this area would be fruitless without the inadvertent sediment trapping effect of the road crossing.

Streambank stabilization using plantings of woody vegetation (cuttings) or more involved bioengineering techniques (e.g. brush layer systems, wattling, timber cribwalls, etc.) can also be attempted along eroding streambanks, especially those supplying a large percentage of silt to the channel. Revegetation is hampered in this area by shady conditions under the riparian forest canopy. As an alternative to a living revetment,

large logs and roots wads could be anchored to the bank (using rocks, cable or rebar) to stem erosion in this area. Other erosion control measures should also be applied to gullied areas in upland sites along the Mill Creek corridor since these are currently supplying large quantities of fine sediment to the channel.

### **Site Design and Stream Fishery Conditions**

On one hand, the development of the Washington State University campus along Mill Creek and Salmon Creek will improve conditions in these streams through the removal of agricultural activities, and the pollution associated with this type of land use, from this part of the basin (Dunne and Leopold 1978, Meyers et al 1985). On the other hand, development of this site could potentially reduce local ground water recharge (which contributes to summer streamflow) and help to increase the incidence of bankfull flows. Site development could also potentially increase the supply of urban contaminants (heavy metals and hydrocarbons) to the creeks while at the same time continuing some level of discharge of fertilizers and pesticides (for landscaping) to local surface waters (Ferguson 1991, Schueler 1991). Thus, while waterside areas (which will be left in a "natural" state and even restored) will be protected and improved by development of the campus, the style of development on remaining portions of the site not directly linked to the stream is still directly relevant to the health of the fishery.

In order to mitigate any stream/fish impacts associated with site development, soil loss to receiving streams must be prevented during the construction stages of this project. Biofiltration of contaminated surface runoff from impervious surfaces should be provided in order to maintain water quality to the maximum extent possible. Of equal if not greater importance, in part because it is not so widely recognized, is the need to enhance infiltration and groundwater recharge on the site in order to maintain this area's contribution to summer baseflow in down-gradient streams. Runoff from impervious surfaces should be discharged to the ground for recharge purposes wherever possible. For example, essentially uncontaminated roofwater can be used to directly recharge local groundwater supplies instead of being routed to detention basins (Ferguson 1991). In addition, much of the site could employ naturalistic landscaping, which maintains unbuilt surfaces in a condition which will accept rainfall without surface runoff. Sloping manicured lawns, on the other hand, act almost like impervious surfaces; a large proportion of rainfall runs off turf surfaces and this tendency generally increases as the lawn ages.

Campus development using the general mode of site design and stormwater management described above can serve as a model to be applied to new developments within the Salmon Creek basin. Retrofitting for local recharge should also be applied wherever possible in already built parts of the basin. Otherwise, channel scouring by frequently recurring bankfull flows and reduced or lost dry season flow may well turn out to be the most insidious impact to the Salmon Creek fishery over the long term.

### **Outlook**

The restoration and long-term survival of salmon and trout (and the other organisms vitally associated with these species) in Salmon Creek and its tributaries is clearly dependent on the adoption of an integrated, watershed approach to future land use changes in the Salmon Creek basin generally and in the Mill Creek subbasin specifically. Streams reflect general watershed condition. Poor watershed condition in the Salmon Creek basin is immediately evident from excessive stream turbidity during rainstorms, the extensive burial of stream gravels and infilling of slackwater areas by silt, widespread channel bank erosion because of the absence or depleted condition of streamside vegetation, and the absence of much pool habitat and instream cover for fish. Although factors such as escapement (ocean survival and return to freshwater for spawning) must play a role, the depleted salmonid populations of this basin must reflect, in large measure, the deteriorated condition of the watershed (Clark County Conservation District 1989, Schlosser 1991).

Local stream corridor enhancement efforts, fishing restrictions, and restocking efforts will ultimately be fruitless without some type of landscape-level approach to future development in the Salmon Creek basin. Area-wide efforts must be made to strictly control sediment contamination of the creek, whether it be from remaining forestlands, farmlands or urban construction sites. A similar level of effort must be made to control summer water temperatures (by riparian area revegetation) in addition to other types of pollution.

The magnitude of fluctuations in stream discharge must also be minimized to the fullest extent possible. Seasonally dry channels can potentially function as spawning areas if they are flooded long enough during the right time of the year. However, streams are obviously devoid of habitat value to fish when they are dry. The extent and duration of channel dewatering can only increase if efforts are not made to preserve groundwater recharge areas and surface water flood storage areas, particularly in the headwaters portions of the basin's streams (Dunne and Leopold 1978, Ferguson 1991, Schueler 1991).

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Geotechnical Resources Incorporated

Consulting Engineers & Geologists

April 28, 1992

JAFINRPT-1.040

Zimmer Gunsul Frasca Partnership  
320 SW Oak Street, Suite 500  
Portland, OR 97204

Attention: Paddy Tillett

**SUBJECT: PRELIMINARY GEOTECHNICAL INVESTIGATION, WASHINGTON STATE  
UNIVERSITY VANCOUVER CAMPUS MASTER PLAN, CLARK COUNTY,  
WASHINGTON**

At your request, Geotechnical Resources, Inc. (GRI) has performed a preliminary geotechnical investigation at the site of the proposed Washington State University (WSU) Vancouver campus located in Clark County, Washington. The Vicinity Map, Figure 1, shows the general location of the site. The investigation was conducted to evaluate subsurface conditions at the site and to provide general comments and recommendations to assist in the preparation of a project master plan. This report describes the work accomplished and presents our conclusions and recommendations to assist in the site development and master plan preparation.

## **PROJECT DESCRIPTION**

It is our understanding that development of the proposed WSU Vancouver campus will occur in several phases. Development of the main campus will be concentrated on the western portion of the site with extension service facilities planned for the northeast corner of the site. Preliminary information indicates that buildings will not exceed four stories in height. Underground and surface parking are being considered as options. The location of access roads, utilities, and other infrastructure needs are still being evaluated.

## **SITE DESCRIPTION**

### **General**

The site of the proposed WSU Vancouver campus consists of approximately 350 acres situated about 7 miles northeast of the Vancouver city center in Clark County, Washington. As indicated on the Site Plan, Figure 2, the property is bounded by NE 50th Avenue to the east, NE Salmon Creek Street to the south, and NE 29th and NE 30th avenues to the west. Mill Creek flows from north to south through the eastern portion of the property, and a Bonneville Power Administration (BPA) transmission line with associated 250-ft-wide easement bisects the property from north to south. The majority of the property

appears to have been used for agricultural purposes in the past. An old dairy farm is situated on the southern portion of the site along NE Salmon Creek Street, and two residences are located approximately 800 ft north of the dairy. In addition, what appears to have been an old homestead is located in the northeast corner of the site. A well house still stands at the homestead site. It is our understanding that the two residences and associated property are not currently part of the proposed campus site.

Vegetation across the majority of the site consists of grasses associated with past agricultural uses of the property. Drainage ravines are typically vegetated with a mixed deciduous and coniferous forest.

### **Topography**

Our observations at the site and a review of available topographic maps indicate that with the exception of the northeast corner of the property, which is relatively flat to gently undulating, the site generally slopes down from west to east toward Mill and Salmon creeks. Ground surface elevations range from about 460 ft along NE 30th Avenue to about 130 ft along NE Salmon Creek Street near the location of the old dairy farm. Slopes on the western portion of the property, including the area considered most likely to be developed, are typically within the range of 5 to 15°. Steeper slopes, up to 35° locally, are present within the various drainage ravines across the site.

### **Geology**

Geologic units in the vicinity of the project site consist of upper Pleistocene-age fine-grained and sand-sized lacustrine deposits, Holocene to upper Pleistocene-age alluvium, and the older Troutdale Formation whose age range is uncertain in this area. The lacustrine deposits, which consist of unconsolidated sand, silt, and clay, mantle most of the lowlands in the area at elevations up to about 350 to 375 ft. This material was deposited in the Portland area by numerous glacial-outburst floods from glacial Lake Missoula between about 15,300 to 12,700 years ago. The Holocene- to upper Pleistocene-age alluvium consists of medium- to fine-grained sand and silt on the Columbia and Willamette River floodplains and sand and gravel on the floodplains of the tributary streams, including Salmon Creek. The Troutdale Formation in the area of the project site consists of conglomerate composed mostly of Columbia River Basalt, with lesser amounts of other volcanic rocks and quartzite. In localized areas, the surface of the Troutdale Formation is severely weathered and the original character of the rock has been destroyed.

## **GEOLOGIC RECONNAISSANCE**

### **General**

A ground-level geologic reconnaissance of the site was conducted on February 27, 1992, by a registered engineering geologist and a geotechnical engineer from our firm. The purpose of the reconnaissance was to observe and evaluate materials exposed at the ground surface and to identify geologic conditions that may affect development of the site for buildings, utilities, and roadways. The approximate traverse route of the reconnaissance is shown on the Reconnaissance Map, Figure 3, as are the geologic conditions, potential hazards, and areas of concern. Edited reconnaissance notes are provided in Appendix A.



## **Surface Conditions**

The predominant surface soil observed during the reconnaissance is brown silt that contains varying percentages of sand (trace to sandy) and a trace to some clay. Gravelly and cobbly soils were noted along a portion of the western edge of the property along NE 30th Avenue and on the portion of the site in the vicinity of the old dairy along NE Salmon Creek Street.

## **SUBSURFACE CONDITIONS**

### **General**

Subsurface materials and conditions on those portions of the site considered most likely to be developed were investigated on March 24, 1992, with 10 backhoe-excavated test pits. The approximate locations of the test pits, designated TP-1 through TP-10, are shown on the Site Plan, Figure 2. The test pits were excavated to depths in the range of 10 to 16 ft. Details of the field and laboratory testing programs are provided in Appendix B. Logs of test pits TP-1 through TP-10 are shown on Figures 1B and 2B.

### **Soils**

For the purpose of discussion, the soils disclosed by the borings have been grouped into the following categories:

- 1. SILT**
- 2. Sandy SILT/Silty SAND**
- 3. Weathered GRAVEL**

The following paragraphs provide a detailed description of each of these soil units and a discussion of the groundwater conditions at the site. The terms used to describe the soils are defined in Table 1B.

**1. SILT.** Brown silt with a trace to some sand and a trace of clay was encountered at the ground surface in the eight test pits (TP-3 through T-10) located on the western portion of the property. This unit extended to depths in the range of 5 to 13.5 ft below the ground surface. Test pits TP-5, TP-6, and TP-8 were terminated in this material at a depth of 10 ft below the ground surface. Torvane shear strength values of 0.25 to 1.4 tsf indicate the relative consistency of the silt ranges from medium stiff to very stiff. The natural moisture content of the soil ranges from 23 to 39% and averages 28%. The color of this unit tends to change from brown to brown mottled gray and rust at depths of 2 to 4 ft below the ground surface. One-dimensional consolidation testing performed on two samples of this material indicates that the preconsolidation pressure of the silt is in the range of 1.2 to 1.4 tsf. The test data also indicate that the compressibility of the silt is low in the range of the preconsolidated pressures and moderate in the range of loads above the preconsolidation pressure.

**2. Sandy SILT/Silty SAND.** Brown to grayish-brown sandy silt to silty sand with occasional rust mottling was encountered at the ground surface in test pits TP-1 and TP-2 and at a depth of 8 ft in test pit TP-10. This material extends to the bottom of the three test pits. Natural moisture contents at the time of our exploration were in the range of 15 to 44%. Torvane shear strength values of 0.10 to 0.45 tsf

indicate the relative consistency of the soil ranges from very soft to medium stiff; however, the lower strength values are likely indicative of higher percentages of sand rather than a decrease in relative consistency.

**3. Weathered GRAVEL.** Dense, brown gravel in a matrix of sand with some silt and a trace of clay was encountered below the silt soils in test pits TP-3, TP-4, TP-7, and TP-9 at depths ranging from 5 to 13.5 ft. The gravel is rounded to subrounded, has a gradation of fine to coarse, and is severely weathered. Many of the individual gravel pieces can be crumbled under moderate finger pressure. This material appears to comprise the upper surface of the Troutdale Formation. The moisture content of this material is in the range of 31 to 50%.

### **Groundwater**

Groundwater seepage was noted at depths of 6.5, 7.5, and between 11 and 12 ft in test pits TP-5, TP-6, and TP-10, respectively. In our opinion, this seepage is associated with a perched water table that will fluctuate with the amount of precipitation. Perched groundwater may approach the ground surface during periods of heavy or prolonged rainfall.

Surface water, in addition to that associated with the well-defined drainage ravines, was also observed at the site. The surface water is concentrated on the southwest portion of the site, in the vicinity of the old dairy farm. Several springs exist on the east-facing slope located to the west of the dairy farm, and areas of ponded water are present on the low-lying portion of the property along Salmon Creek Street.

## **CONCLUSIONS AND RECOMMENDATIONS**

### **General**

The results of our subsurface investigation and geologic reconnaissance at the site of the proposed WSU Vancouver campus indicate that the majority of the site is mantled with soils of low to moderate compressibility consisting of silt and/or sandy silt to silty sand. These fine-grained soils are 5 ft to more than 16 ft thick and are underlain by severely weathered gravel of the Troutdale Formation on the western portion of the property. For construction and site grading purposes, the severely weathered gravel should be expected to behave more like a fine-grained soil than a granular soil.

Groundwater was encountered in three of the test pits on the western portion of the property at depths ranging from 6.5 to about 11 ft. In our opinion, this groundwater is a perched condition that may approach the ground surface during periods of heavy or prolonged precipitation. Springs and areas of poor surface drainage were observed at the site and are concentrated on the southeastern portion of the property, which is not currently being considered for development.

In our opinion, the property is suitable for development of the WSU Vancouver campus. However, due to the presence of locally steep slopes, areas of poor surface drainage and fine-grained surface soils, the design and construction must carefully consider site conditions. The following recommendations and conclusions address areas of concern and are provided to assist in the planning and development of a

campus master plan. We recommend that site-specific subsurface explorations be performed prior to the design and construction of individual structures so that specific design and construction recommendations can be provided for the individual structures.

### **Site Preparation and Grading**

We recommend that the ground surface within and approximately 10 ft beyond building and pavement limits be stripped of vegetation, tree stumps, and surface organics. The heavily rooted zone present at the ground surface should be stripped to a depth of about 6 in. Greater amounts of stripping may be required locally.

Past experience has indicated that the fine-grained soils disclosed by the subsurface investigation are sensitive to moisture content. Typically, when these soils are in excess of 4 to 5% of their optimum moisture content, they become weak and unstable when remolded by construction traffic. For this reason, we recommend that all site preparation and earthwork be accomplished during the dry summer months, typically extending from mid-May to mid-October of any given year. If construction is to proceed during the wet months of the year, we recommend that all construction traffic be limited to movement on granular work pads. We further recommend that any excavation during this time of year be performed using large hydraulic excavators (backhoes), in lieu of scrapers and/or bulldozers, to prevent softening of the subgrade soils. Also, the contractor should plan the earthwork operations such that construction equipment, i.e., bulldozers, dump trucks, etc., does not traffic the fine-grained surface soils. This will require the placement of imported granular fill for a working pad as the earthwork progresses. If the subgrade is disturbed during construction, soft, disturbed soils should be overexcavated to firm soil and backfilled with compacted granular materials.

### **Structural Fill**

In our opinion, the on-site, organic-free, fine-grained soils (silt, sandy silt to silty sand, and weathered gravel) are suitable for use in constructing structural fills. However, as previously mentioned, fine-grained soils are sensitive to moisture content and should be placed only during the dry summer and early fall months. If construction is to proceed during the wet winter and spring months, fills should be constructed using imported, relatively clean, granular materials.

In general, approved, organic-free, fine-grained soils used to construct structural fills should be placed in 9-in.-thick lifts (loose) and compacted using pneumatic or segmented-pad rollers to a density not less than 95% of the maximum dry density as determined by ASTM D 698. Fill placed in landscaped areas should be compacted to a minimum of 90% of ASTM D 698. In our opinion, the moisture content of fine-grained soils at the time of compaction should be controlled to within  $\pm 3\%$  of optimum. Some aeration and drying of the on-site, fine-grained soils may be required to meet the above recommendations for compaction.

Imported granular material used to construct structural fills or work pads during wet weather should consist of material with a maximum size of up to 6 in. and with not more than about 5% fines passing the No. 200 sieve (washed analysis). The first lift of granular fill material placed over the silt subgrade

should be in the range of 12 to 18 in. thick (loose). Subsequent lifts should be placed 12 in. thick (loose). All lifts should be compacted with a medium-weight (48-in.-diameter drum), smooth, steel-wheeled, vibratory roller until well keyed. Generally, a minimum of four passes with the roller is required to achieve compaction.

## **Utilities**

**General.** Based on existing utility information provide by Parametrix, Inc., we understand that new utility trenches will be limited to a depth of less than about 10 ft. In our opinion, there are four major considerations in the design and construction of new utilities.

1. Provide positive control of groundwater to maintain stable trench sides and bottom.
2. Provide stable excavation side slopes or temporary support for trench sidewalls to minimize loss of ground or damage to adjacent improvements.
3. Provide a safe working environment during construction.
4. Minimize post-construction settlement of the ground surface and the utility.

In our opinion, the most significant subsurface condition that may affect the construction of new utilities at the site is the presence of groundwater within the excavations. As previously indicated, groundwater levels at the site fluctuate in response to seasonal precipitation. As a result, groundwater may be encountered within the excavations depending on the depth of the utilities and the construction schedule.

**Excavation and Shoring.** The method of excavation and the design of the trench support is the responsibility of the contractor and subject to applicable local, state, and federal safety regulations, including the current OSHA excavation and trench safety standards. The means, methods, and sequencing of construction operations and site safety is also the responsibility of the contractor. The information provided below is for the use of the client and should not be interpreted to mean that we are assuming responsibility for the contractor's actions or site safety.

The majority of the soils encountered within our subsurface explorations along the proposed alignment may be classified as Type B or Type C soil according to the most recent OSHA regulations. In our opinion, trenches less than 4 ft deep in the medium stiff to stiff silt may be cut vertically and left unsupported during the normal construction sequence, i.e., assuming trenches are excavated and backfilled in the shortest possible sequence and excavations are not allowed to remain open longer than 8 hours. Excavations in the range of 4 to 20 ft deep should be laterally supported or alternatively provided with stable side slopes. The contractor should be aware that all excavation and shoring should conform to the requirements specified in the applicable local, state, and federal safety regulations, e.g., OSHA Health and Safety Standards for Excavations, 29 CFR Part 1926, or successor regulations. We understand that such regulations are being strictly enforced, and, if not followed, the contractor may be liable for substantial penalties.

We anticipate that advancing the excavations using a conventional shield will likely be the most economical method of construction. However, if this method is used, it is our opinion that the contractor limit the length of open trench. The use of tight-joint, driven steel sheet piling may be necessary to control seepage and prevent ground loss near any existing improvements.

The control of groundwater to prevent the loss of running soils should be considered when developing the excavation and shoring plans. Besides the obvious safety considerations, running soils or other loss of ground will result in increased backfill volumes and could result in damage to existing improvements adjacent to the excavation.

**Control of Groundwater.** In our opinion, positive control of groundwater encountered during excavation and construction will be necessary to maintain stable trench sides and bottom. For example, if sand or sandy silt soils are exposed below the groundwater table, running soils and caving conditions are likely to occur. The control of groundwater will depend on the types of materials and groundwater levels encountered in the excavations. We anticipate that relatively small groundwater inflows will be encountered in the silt soils; larger inflows and possibly running soil conditions may be encountered in sands or sandy silt soils. In our opinion, dewatering across the majority of the site can be accomplished by pumping from sumps. In those areas where sandy soils and running soil conditions may be encountered and cannot be tolerated, other methods of groundwater control may be necessary, such as pumping from wells or well points installed adjacent to the excavation or using tight-joint sheet piling for excavation support.

**Trench Bottom Stabilization.** If groundwater is encountered within utility excavations, it will be necessary to overexcavate the trench bottom to permit installation of a granular working blanket to prevent bottom instability and facilitate pumping from sumps. We estimate that the required thickness of the granular working blanket will be on the order of 1 ft, or as required to maintain a stable trench bottom, depending on the conditions exposed in the trench and the effectiveness of the contractor's dewatering efforts. The thickness of the granular blanket must be evaluated on the basis of field observations during construction. We recommend that relatively clean, free-draining material, such as 2- to 4-in.-minus crushed rock, be used for this purpose.

**Backfilling.** All utilities that will be beneath future improvements should be backfilled with relatively clean, i.e., less than about 5% passing the No. 200 sieve (washed analysis), granular fill. All utility trenches should be backfilled as soon as practical following placement of the utility. The granular backfill should be compacted to 95% of the maximum dry density (ASTM D 698) in the upper 6 ft of the trench and to 90% compaction below this depth. Flooding or jetting of the backfill should not be allowed.

**Settlements.** In our opinion, backfilling all utility excavations with relatively clean, compacted granular fill should minimize post-construction settlement of the ground surface. However, inadequate removal of disturbed, soft, and loosened materials prior to installation of the granular working blanket may result in post-construction settlement of the soils and utilities. Subgrade disturbance can be caused by bottom instability, foot traffic, or other construction activities. Additional measures to minimize softening of the

trench bottom and settlement would involve construction practices, such as 1) preventing water from ponding in the bottom of the trench, and 2) completing trench excavation, pipe placement, and backfilling in the closest practical sequence.

### **Cut and Fill Slopes**

Cut and fill slopes should not exceed 2H:1V. Fill should be placed and compacted a minimum distance of 2 ft beyond the final slope grade and then trimmed back to the final grade. Past experience indicates that fine-grained soils exposed in cut and fill slopes are susceptible to surface erosion. Fill slopes tend to be more susceptible to erosion than cut slopes. Surface drainage should be directed away from the slopes and cut and fill slopes should be protected from erosion by a vigorous plant growth. It may be necessary to install mulch or a re-vegetation mat/fabric to enhance plant growth and retard erosion.

We recommend that structures be set back a minimum distance of 10 ft from a line that would extend up from the toe of the slope at 2H:1V. This recommendation applies to cut and fill slopes constructed at 2H:1V and the steeper natural slopes associated with existing drainage ravines.

### **Foundation Support**

Foundation support for campus buildings can be provided by conventional wall- and column-type spread footings. We estimate that footings established in firm, undisturbed silt or sandy silt to silty sand soils can be designed on the basis of an allowable bearing pressure in the range of 2 to 3 ksf. Footings established in the dense, severely weathered gravel can be designed on the basis of an allowable bearing pressure in the range of 4 to 5 ksf. Typically footings should be founded at a minimum depth of 1½ ft below the lowest adjacent finished grade. Minimum footing widths will be on the order of 18 in. for wall footings or 24 in. for isolated column footings.

We estimate that the total settlement of spread footings designed in accordance with the recommendations presented above will be less than 1 in. Differential settlements between adjacent footings should be less than half the total settlement. Past experience indicates that these settlements will occur rapidly, with the majority of the settlement occurring during construction.

### **Subdrainage/Floor Support**

In our opinion, groundwater levels during the winter season may be expected to rise to near the ground surface at any building location on the property. Therefore, we recommend that buildings embedded below existing site grades be provided with subdrainage systems to reduce hydrostatic pressure and the risk of groundwater entering through embedded walls and floor slabs.

The basic elements of a subdrainage system for embedded structures are shown on Figure 4. The figure shows peripheral subdrains to drain embedded walls and an interior granular drainage blanket beneath the concrete floor slab which is drained by a system of subslab drainage pipes. All groundwater collected should be drained by gravity or pumped from sumps into the storm sewer system. If the water is pumped, an emergency power supply should be included to prevent flooding due to a power loss.

In areas where the finish floor elevation will be above existing site grades, a minimum of 8 in. of free-draining, clean, granular material should be placed beneath all concrete slabs. The granular material should minimize the potential for capillary rise of water beneath the concrete slabs. In addition, it may be necessary to install a suitable vapor-retarding membrane beneath slab-on-grade floors. Details of a vapor retarding system are also presented on Figure 4.

### Erosion and Drainage

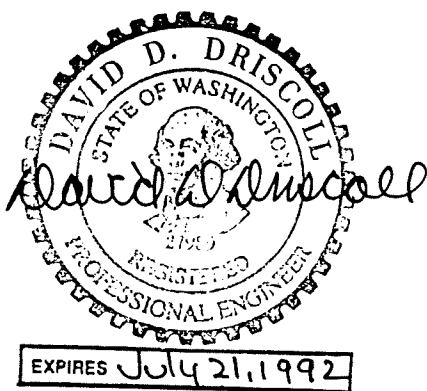
During our reconnaissance, no significant erosion was noted on undisturbed drainage ravine slopes. However, significant erosion and oversteepening of stream banks has occurred where streamside vegetation has been destroyed by cattle. The potential for increased stream flows and continued erosion of these oversteepened banks exists with on-site disposal of storm water. For this reason, it would be desirable to discharge the storm runoff to drainage ravines that have experienced minimal erosion, or to a point downstream of the oversteepened bank areas. The potential for accelerated erosion as a result of increased stream flows exists. However, the rate of increase can realistically only be evaluated by monitoring the stream channel following site development. Feasible remedial measures to prevent continued erosion in badly damaged areas could include the installation of small sediment-retention and velocity-reduction structures. Gabion structures (rock-filled wire baskets) or similar-type construction would be suitable for this application.

### LIMITATIONS

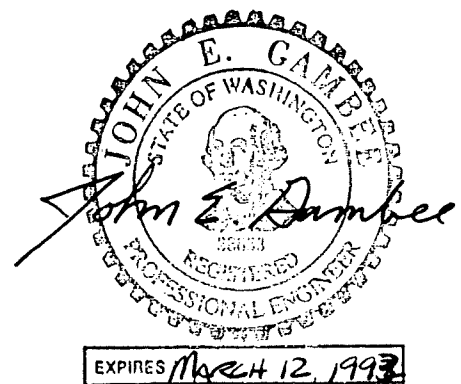
This report has been prepared to aid the architect in the preliminary design and master planning of this project. The scope is limited by the fact that actual plans for development are indefinite; hence, only preliminary opinions are presented. Significant limitations are inherent in a study of this type, and additional site investigations must be conducted as specific construction plans and designs are developed.

Sincerely,

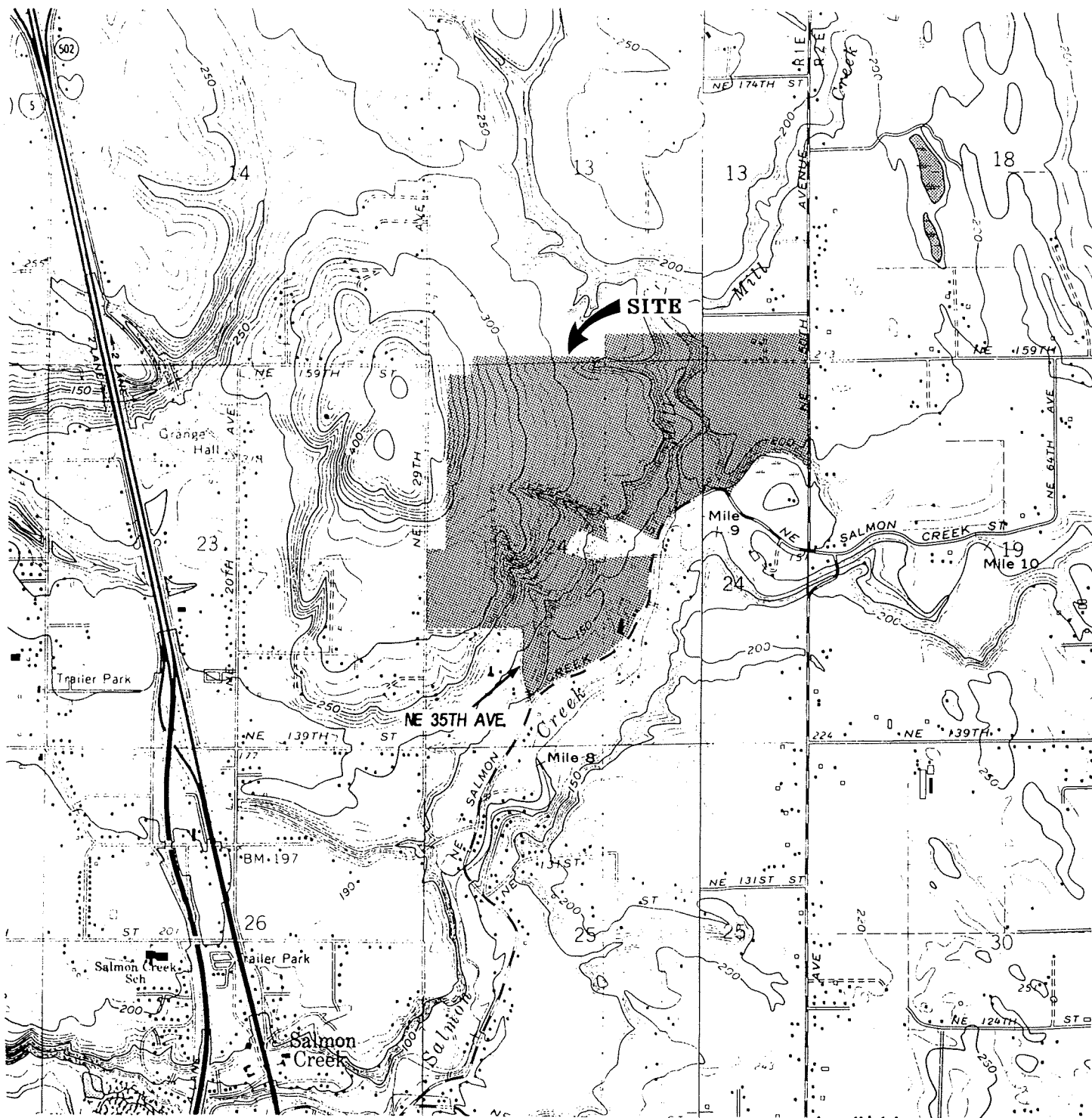
GEOTECHNICAL RESOURCES, INC.



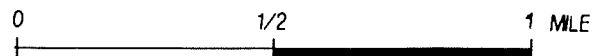
David D. Driscoll, P.E.  
Principal



John E. Gambee, P.E.  
Project Engineer



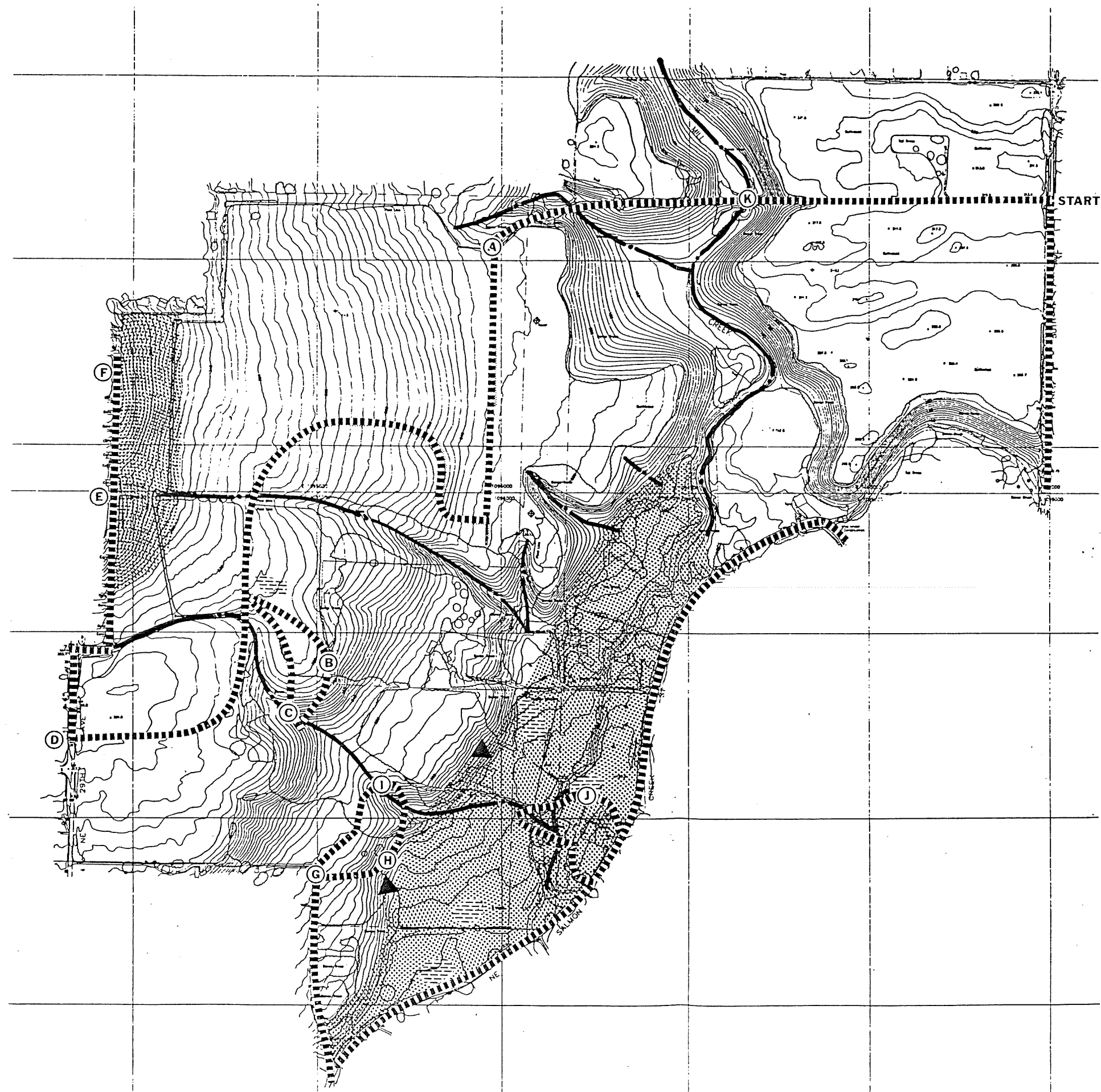
USGS TOPOGRAPHIC MAP  
ORCHARDS & VANCOUVER, WASH. QUADS



ZIMMER GUNSUL FRASCA PARTNERSHIP  
WSU VANCOUVER CAMPUS

VICINITY MAP





- Geologic Reconnaissance (February 27, 1992)
- Ponded Water
- ▲ Springs
- Gravelly/Cobbly Soils
- Existing Drainage
- Ⓐ Reconnaissance Reference Point

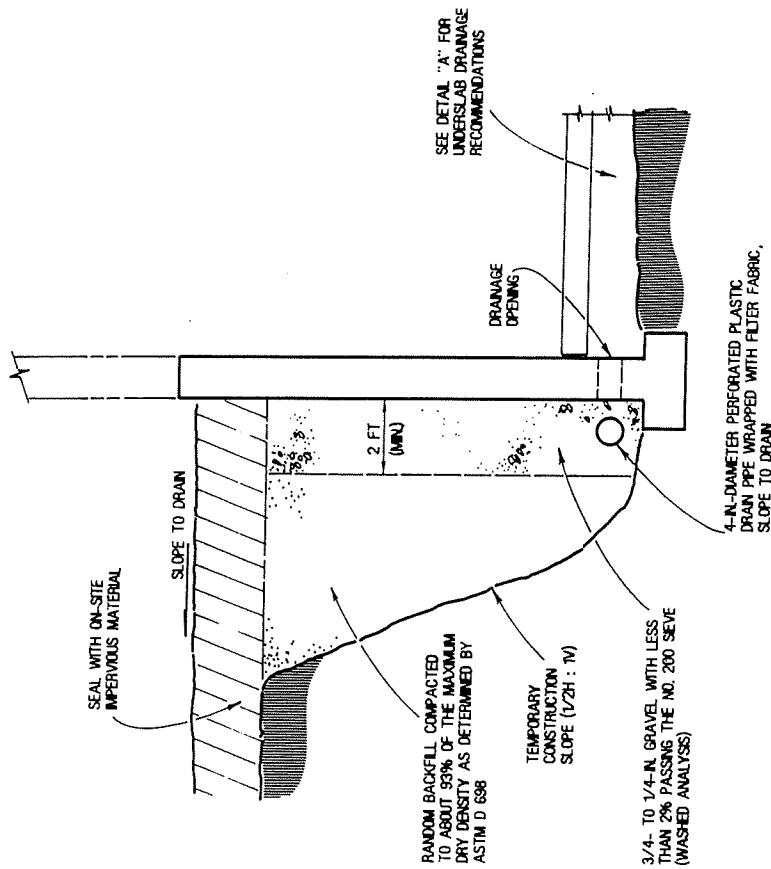


0 600 1200 FT

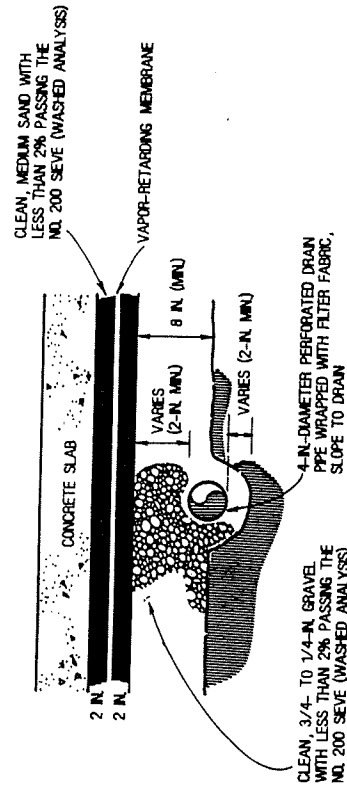


ZIMMER GUNSUL FRASCA PARTNERSHIP  
WSU VANCOUVER CAMPUS

RECONNAISSANCE MAP



PERIMETER DRAIN



DETAIL "A"

NOT TO SCALE

NOTE: INTERNAL 4-IN-DIAMETER PERFORATED DRAIN PIPES ARE TYPICALLY PLACED ON 20-FT CENTERS AND SLOPED TO DRAIN

THE VAPOR-RETARDING MEMBRANE AND CLEAN SAND LAYERS ARE RECOMMENDED FOR MOISTURE SENSITIVE AREAS

UNDERSLAB DRAIN



ZIMMER GINSII FRASCA PARTNERSHIP  
WSU VANCOUVER CAMPUS

# TYPICAL SUBDRAINAGE DETAIL

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## **APPENDIX A**

**APPENDIX A**  
**FIELD RECONNAISSANCE NOTES**

**WSU Vancouver Campus**  
**Conducted on February 27, 1992**  
**by John Gambée and Robin Warren**

Starting at the intersection of NE 50th Avenue and NE 159th Street, we are heading west along a dirt access road through the northeast corner of the site. The topography is flat to gently undulating. The property to the north and south of the roadway is currently being farmed. Vegetation is some type of field grass. Surface soils are fine grained; typically silts. What appears to be an old homestead is situated north of the dirt access road on which we are travelling, approximately 600 to 700 ft west of NE 50th Avenue. All buildings, with the exception of a pump house, are gone.

Continuing west, we enter a coniferous forest and proceed downward into the Mill Creek drainage. An earth embankment with a large-diameter (estimated at 10 ft) CMP culvert has been constructed as a creek crossing. We continue on the dirt road up the west side of the drainage ravine.

Continuing west, we pass under the BPA transmission line and reach a gate (point A) approximately 250 ft past the transmission line. We are at the northern edge of a large field which generally slopes from west to east. The area north of the gate is a treed drainage ravine. We noted a concrete pipe (possibly a field drain) discharging water into the ravine. Soil exposed in the ravine slope below the pipe consists of a brown, sandy silt. The soil appears stiff to very stiff. Some fill has been piled at the top of the slope and some dumped over the edge. Six photos were taken from the gate looking west to southeast.

From the gate, we are travelling south across the open field parallel to the BPA transmission line and traversing the slope. The ground is relatively firm. Upon reaching the tree line which borders a west- to east-trending drainage ravine, we turn west and head upslope to the tree line. The ground becomes wetter and softer, so we backtrack to the north before continuing west. Approximately two thirds of the way up the slope, we turn south and cross a shallow ditch which appears to be the start of the east- to west-trending drainage ravine. Travelling farther south, we stop before a second ditch which also appears to be associated with a west- to east-trending drainage. On foot, we walk east toward a break in the brush. We stop at a fence line (point B) and look downslope to the east toward the two "out" parcels of property. From this point, we take three photos to the east and three photos to the west.

We continue walking, this time down to the south following a fairly well established trail which leads down into the second east- to west-trending drainage ravine. Vegetation (brush and overstory) is relatively thick on the side slopes. Surficial soils are relatively loose. One photo is taken at the bottom of the ravine (point C) looking upstream. On our way back up the north side of the ravine (about mid-slope), we encountered a shallow (approximately 3-ft-deep) excavation. Soils exposed are silt with a trace of fine sand. We return to the pickup.

Driving south, we cross the second drainage ditch and enter the field located in the southwest corner of the property. Approximately halfway across the field we turn west and head toward NE 29th Avenue. An open gate allows access to NE 29th Avenue. We stop and take five photos looking to the east (point D).

We now drive north on NE 29th and NE 30th avenues. We took two sets of photos from NE 30th Avenue; five photos from point E looking east and four photos from point F looking east. Observed gravelly soils from recent construction along NE 30th Avenue.

We drive up NE 35th Avenue to the north from NE Salmon Creek Street. Stopped at driveway near end of road (point G) and took six photos looking northwest to southeast. Photos show fields, trees, and the back side of the old dairy.

Proceeding north to the end of the road (NE 35th Avenue), we then pass through a gate on foot and head east. A spring is observed on an east-facing slope west of the old dairy (wetland grasses observed) (point H). Four photos taken. Ponded water is observed on the relatively flat portion of the site south and west of the dairy along Salmon Creek Street.

Heading north from spring area into a stand of fir trees. Observe some type of watering tank with supply lines attached (point I). Observed water flowing in drainage ravine north of watering tank. Return to truck and drive back to Salmon Creek Street. Head northeast on Salmon Creek Street.

Observe ponded water along with wetland grasses and plants along the north side of Salmon Creek Street between NE 35th Avenue and the old dairy; gravelly and cobbly soils noted adjacent to the roadway.

Stopped at dairy entrance. Ponded water observed to the north and west of the dairy. Water coming from drainages in bank behind dairy--photos taken (point J). Gravelly/cobbly soils exposed in the bank behind dairy. It appears that drainages at one time extended to Salmon Creek. On flat portions of site, it appears that defined drainage channels have filled in causing water to spread (fan) out and pond. The area behind the dairy is full of cow manure. Observed additional springs and wetland areas to the northwest of the dairy.

Returned to culvert crossing of Mill Creek (point K). Took several photos. Walked on trail downstream (east side). Embankment approximately 15 ft high; streambed composed of gravel.

## **APPENDIX B**

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## **APPENDIX B**

### **FIELD EXPLORATIONS AND LABORATORY TESTING**

#### **FIELD EXPLORATIONS**

##### **General**

Subsurface conditions and materials at the site were investigated on March 24, 1992, with 10 test pits, designated TP-1 through TP-10. The approximate locations of the test pits are shown on the Site Plan, Figure 2. The test pits were excavated using a rubber-tired backhoe provided and operated by W.G. Moe and Sons of Portland, Oregon. An experienced geotechnical engineer provided by our firm, directed the test pit excavations and maintained a detailed log of the materials disclosed during the course of the work.

The test pits ranged in depth from 10 to 16 ft. Representative soil samples were obtained from the sidewalls of the excavation. The samples were examined and classified, and representative portions were saved in airtight jars. In addition, relatively undisturbed, 3.0-in.-O.D. Shelby tube samples were collected. These samples were obtained by pushing the Shelby tubes into undisturbed soil a distance of approximately 24 in. using the bucket of the backhoe. After retrieval, the ends of the tubes were sealed to prevent moisture loss. All samples were returned to our laboratory for further examination and physical testing. The approximate undrained shear strength of fine-grained soils exposed in the excavation sidewalls was determined using a Torvane shear device. Results of the Torvane shear tests are shown on the Test Pit Logs, Figures 1B through 2B.

Each of the test pit excavations was backfilled with the excavated materials and the backfill graded to match the adjacent ground surface. Minimal compactive effort was applied to the backfill.

##### **Logs of Test Pits**

Detailed logs of test pits TP-1 through TP-10 are presented on Figures 1B and 2B. Each log presents a descriptive summary of the various types of material encountered in the excavations and notes the depth where the materials and/or characteristics of the materials change. To the right of the descriptive summary, sample type and depth along with natural moisture contents and Torvane shear strength values are presented. The terms used to describe the soils are defined in Table 1B.

#### **LABORATORY TESTING**

##### **General**

The samples obtained from the test pits were examined in our laboratory where the physical characteristics of the samples were noted and the field classifications were modified where necessary. At the time of classification, the natural moisture content of each sample was determined. Additional tests included the determination of undisturbed unit weights, Torvane shear strengths, and one-dimensional consolidation testing.

### **Natural Moisture Content**

Natural moisture content determinations were made in conformance with ASTM D 2216. The results are presented on the Test Pit Logs, Figures 1B and 2B.

### **Torvane Shear Strength**

The approximate undrained shear strength of relatively undisturbed soil samples was determined using a Torvane shear device. The Torvane is a hand-held apparatus with vanes which are inserted into the soil. The torque required to fail the soil in shear around the vanes is measured using a calibrated spring. The results of the Torvane shear tests are shown on the Test Pit Logs, Figures 1B and 2B.

### **Undisturbed Unit Weight**

The unit weight, or density, of undisturbed soil samples was determined in the laboratory in substantial conformance with ASTM D 2937. The results of the unit weight determinations are summarized below.

#### **SUMMARY OF UNIT WEIGHT DETERMINATIONS**

<u>Test Pit</u>	<u>Sample</u>	<u>Depth, ft</u>	<u>Natural Moisture Content, %</u>	<u>Dry Unit Weight, pcf</u>	<u>Soil Type</u>
TP-2	S-1	2.5	27	89.7	Sandy SILT
TP-4	S-1	1.8	25	95.6	SILT; some sand
TP-5	S-1	2.7	25	96.0	SILT; some sand
TP-8	S-1	1.3	32	84.8	SILT; some sand
TP-10	S-1	2.5	34	84.7	Sandy SILT

### **One-Dimensional Consolidation Test**

Two one-dimensional consolidation tests were performed in substantial accordance with ASTM D 2435 to obtain data on the compressibility characteristics of fine-grained soils at the site. Test results are summarized on Figures 3B and 4B in the form of a curve showing effective stress versus percent strain. The initial and final moisture content and unit weight were determined in conjunction with the test and are provided at the top of the figures.



**Table 1B**

**GUIDELINES FOR CLASSIFICATION OF SOIL**

**Description of Relative Density for Granular Soil**

<u>Relative Density</u>	<u>Standard Penetration Resistance (N-values) blows per foot</u>
very loose	0 - 4
loose	4 - 10
medium dense	10 - 30
dense	30 - 50
very dense	over 50

**Description of Consistency for Fine-Grained (Cohesive) Soils**

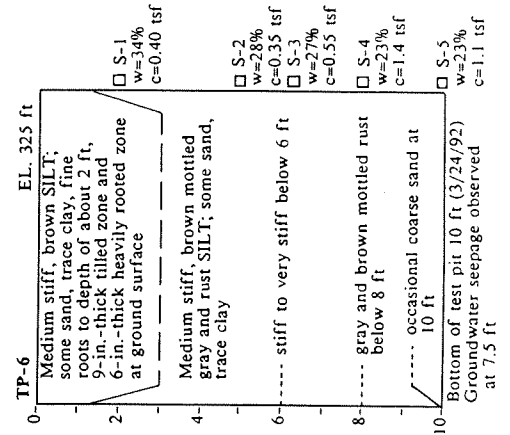
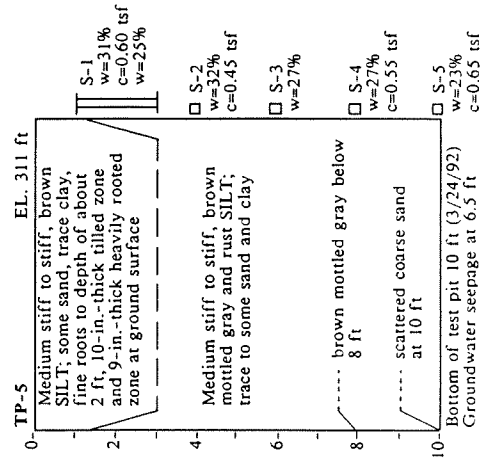
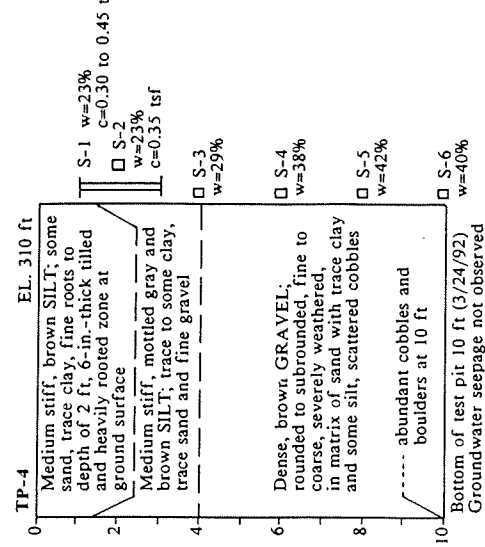
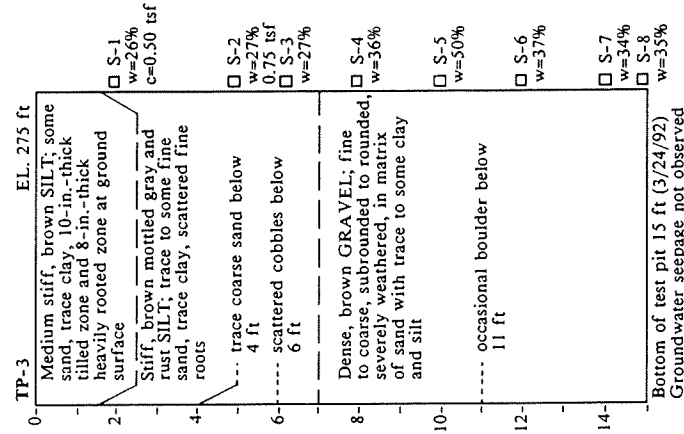
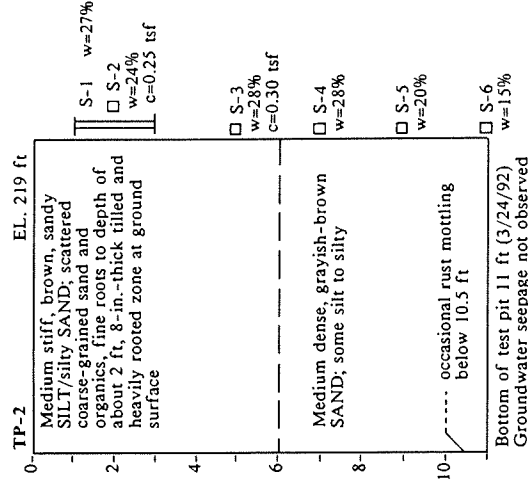
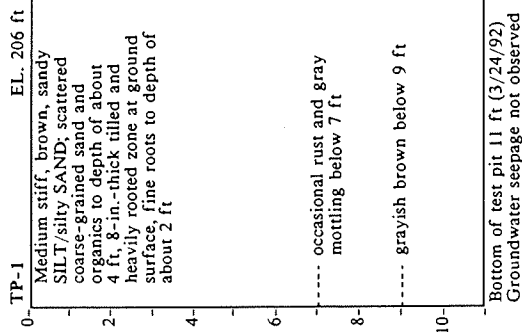
<u>Consistency</u>	<u>Standard Penetration Resistance (N-values) blows per foot</u>	<u>Torvane Undrained Shear Strength, tsf</u>
very soft	2	less than 0.125
soft	2 - 4	0.125 - 0.25
medium stiff	4 - 8	0.25 - 0.50
stiff	8 - 15	0.50 - 1.0
very stiff	15 - 30	1.0 - 2.0
hard	over 30	over 2.0

Sandy silt materials which exhibit general properties of granular soils are given relative density description.

**Grain-Size Classification**

**Modifier for Subclassification**

	<u>Adjective</u>	<u>Percentage of Other Material In Total Sample</u>
Boulders 12 - 36 in.		
Cobbles 3 - 12 in.	clean	0 - 1.5
Gravel 1/4 - 3/4 in. (fine) 3/4 - 3 in. (coarse)	trace some	1.5 - 10 10 - 30
Sand No. 200 - No. 40 sieve (fine) No. 40 - No. 10 sieve (medium) No. 10 - No. 4 sieve (coarse)	sandy, silty, clayey, etc.	30 - 50
Silt/Clay - pass No. 200 sieve		



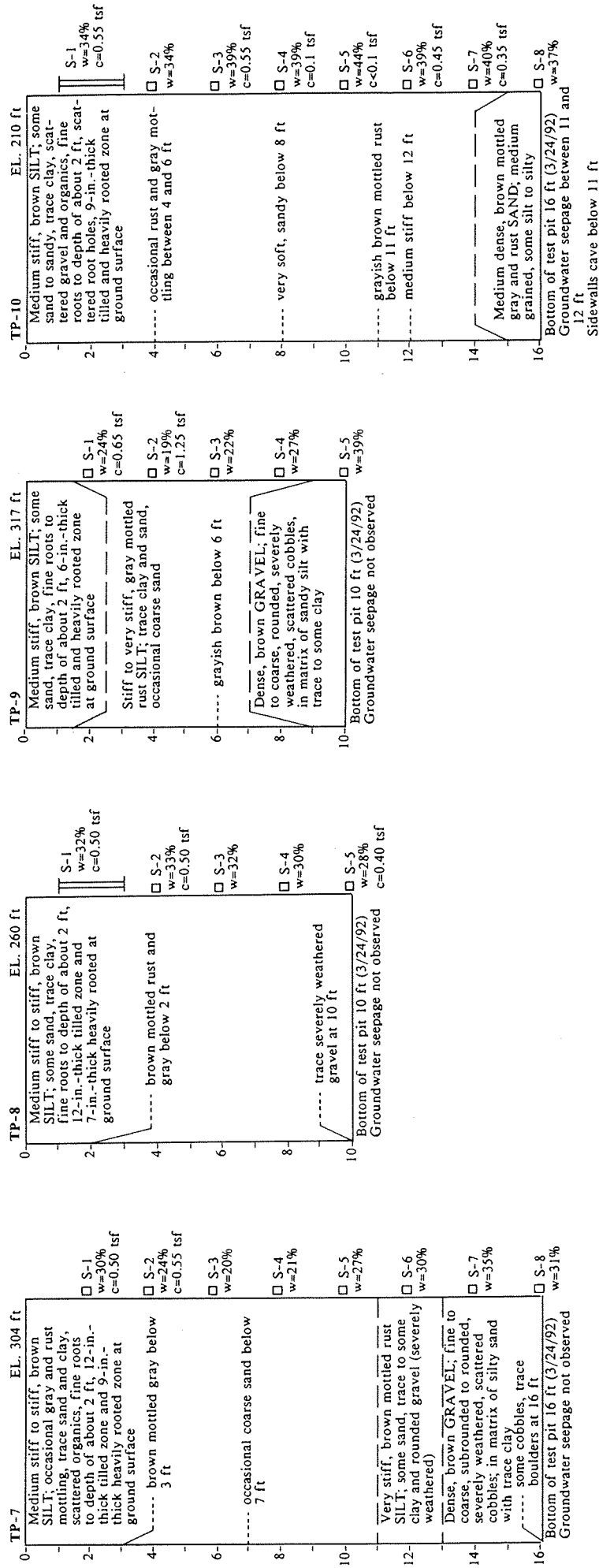
# LEGEND

- = GRAB SAMPLE
- ▮ = 3-IN.-O.D. SHELBY TUBE SAMPLE
- w = NATURAL MOISTURE CONTENT
- c = TORVANE SHEAR STRENGTH

Elevations obtained from topographic map prepared by Walker and Associates dated November 1991



## TEST PIT LOGS



# LEGEND

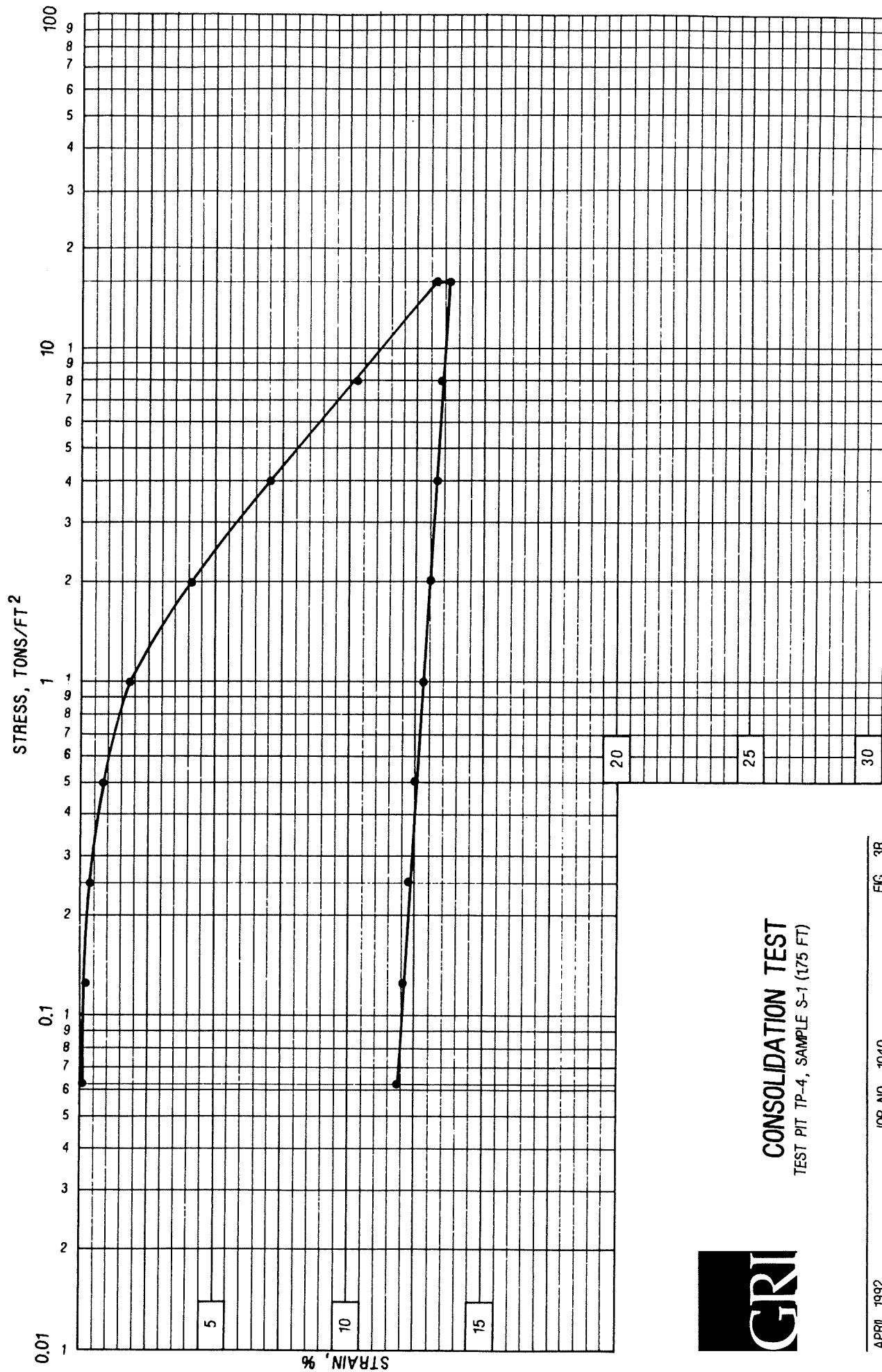
- = GRAB SAMPLE
- ▣ = 3-IN.-O.D. SHELBY TUBE SAMPLE
- w = NATURAL MOISTURE CONTENT
- c = TORVANE SHEAR STRENGTH

Elevations obtained from topographic map prepared by Walker and Associates dated November 1991



## TEST PIT LOGS

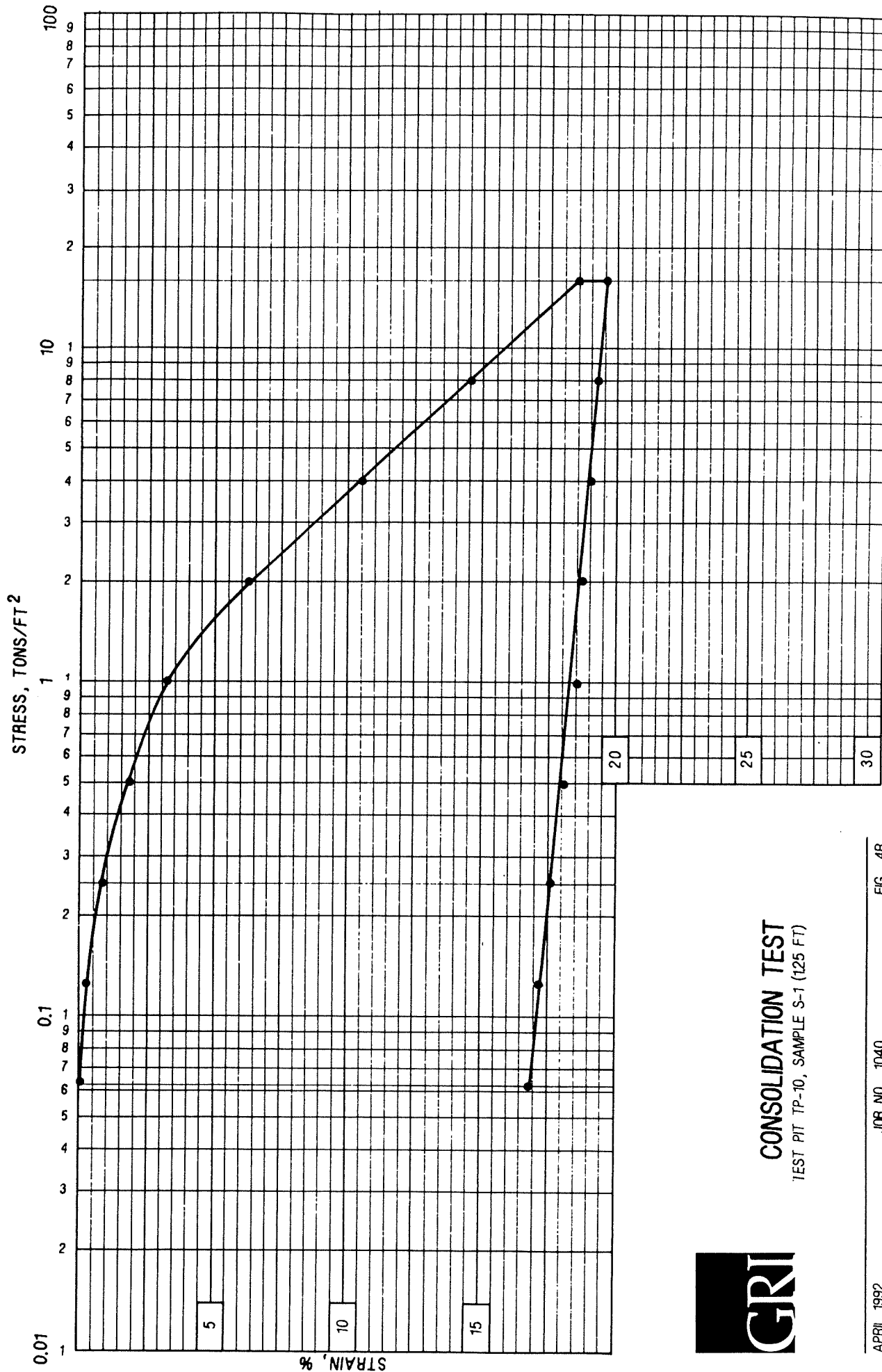
BORING	SAMPLE	DEPTH, FT	MOISTURE CONTENT, % (INITIAL)	MOISTURE CONTENT, % (FINAL)	DRY UNIT WEIGHT, PCF (INITIAL)	DRY UNIT WEIGHT, PCF (FINAL)	SOIL DESCRIPTION
TP-4	S-1	1.75	25	22	95.6	108.4	MEDIUM STIFF, BROWN SILT; SOME SAND, TRACE CLAY, OCCASIONAL FINE ROOTS AND ROOT HOLES



# CONSOLIDATION TEST TEST PIT TP-4, SAMPLE S-1 (1.75 FT)



BORING	SAMPLE	DEPTH, FT	MOISTURE CONTENT, % (INITIAL)	MOISTURE CONTENT, % (FINAL)	DRY UNIT WEIGHT, PCF (INITIAL)	DRY UNIT WEIGHT, PCF (FINAL)	SOIL DESCRIPTION
TP-10	S-1	125	28	26	83.6	100.5	MEDIUM STIFF, BROWN SILT; SOME SAND TO SANDY, TRACE CLAY, SCATTERED GRAVEL AND ORGANICS



# CONSOLIDATION TEST TEST PIT TP-10, SAMPLE S-1 (125 FT)





**Washington State University - Vancouver Campus**  
**Master Utility Plan**  
*(Water, Sewer, and Drainage)*

The following master utility plan was developed in concert with the overall campus master plan developed by the Zimmer, Gunsul, Frasca, Partnership. The focus of this plan is on water needs (domestic, fire and irrigation), sanitary sewer service, and drainage. A complementary master plan addressing power, gas, and communications has been developed by PAE Consultants. The utility needs were examined for each of three phases of campus development (years 1998, 2010, 2025). Relevant flow projections were based on the following headcount populations published in the November, 1991 *Washington State University at Vancouver Project*:

<u>Year</u>	<u>Population</u>
1998	3,104
2010	5,345
2025	10,691

Master water, sewer, and drainage plans for Phases I and II are included at the end of this report.

## **WATER SERVICE**

### **Existing System**

Water is supplied to the proposed WSU campus by Clark County Public Utility District No.1 (PUD) from two separate sources. The Tittle Reservoir, 0.75 million gallons (MG) provides water supply for the north and western portions of the proposed campus site. The Hazel Dell system, consisting of numerous wells and reservoirs, supplies water to the southern portion of the campus site. The overflow elevation for the Wilson/Tittle Reservoirs is 516. The overflow elevation for the Hazel Dell system is 385. The pressure zones for the Tittle and Hazel Dell systems divide the site at approximately elevation 250. Presently, water is boosted to the Tittle reservoir system from the PUD's Wilson Reservoir, 3.0 MG. The PUD is also planning to provide an additional booster pump station that will pump water from the Hazel Dell system up to the Tittle Reservoir. The Clark County Deputy Fire Marshall, Richard Martin, has indicated that connection to the PUD water system will meet the storage capacity requirements for fire protection.

A 10-inch water main from the Tittle system is located along the western boundary of the campus in NE 29th Avenue. Additional 6-inch and 8-inch water lines from the Tittle Reservoir stub into the northwestern portion of the campus from adjacent residential streets. An 8-inch water main from the Hazel Dell system is located in the Salmon Creek Avenue at the south west portion of the campus site.

### Proposed System

The proposed system is intended to meet anticipated campus needs on a phased basis through full development in the year of 2025+. The proposed system considers campus needs for domestic water usage, fire protection, and landscape irrigation. The estimated flows, in gallons per minute (GPM), required for each of the identified three phases are as follows:

Usage Classification	Cumulated Flow by Phase - Gallons Per Minute		
	PHASE I (1998)	PHASE II (2010)	PHASE III (2025)
Domestic	800	1280	3200
Fire Protection	1500	1500	1500
Irrigation*	900	1400	2000

*\* Irrigation requirements can vary considerably depending on system components. There are also existing on-site wells that may be available to meet a portion of the landscape irrigation needs.*

Since Phases I and II are located on the westerly portion of the site, service is proposed from the 10" water main in N.E. 29th Street. A 10-inch loop system is proposed as the main water supply line through the campus. The PUD has expressed a willingness to accept this loop as a public line if it is placed in an easement that will allow them access to maintain the line. This would also be true for internal main line extensions serving other portions of the campus. Individual meters would be provided for separate buildings, or building clusters, as appropriate.

Although portions of the Phase II buildings will be below elevation 250 (in the Hazel Dell pressure zone), it is recommended that pressure reducers be installed at these buildings rather than extend service from the Hazel Dell system in N.E. Salmon Creek Avenue.

Phase III development is proposed on the eastern portion of the campus site. No public water systems are close to this portion of the site. It is anticipated that the public system will be extended into that area by the year 2025; however, the PUD has no specific plans for service extension to the east at this time. Water may be available from existing on-site wells for limited development in the eastern portions of the site before public water is extended into the area.

## **Cost Participation**

Washington State University will be responsible for all on-site water improvements. No off-site improvements are anticipated for Phase I and Phase II development. The type of off-site water main improvements that may be required for Phase III development are typically funded by the PUD.

## **SANITARY SEWER SERVICE**

### **Existing System**

Sanitary sewer service is provided to the campus site by the Hazel Dell Sewer District (HDSD). The HDSD sewer master plans indicates four service basins within the campus site (Mt. Vista, Mill Creek, Pleasant Valley North, and Pleasant Valley South).

The area west of the Bonneville Power Administration (BPA) right of way falls primarily in the Mt. Vista Basin. The 10-inch Mt. Vista Trunk extends down the west side of BPA right of way and connects to the Salmon Creek Interceptor at N.E. Salmon Creek Avenue.

The area east of the BPA right of way is divided between the Mill Creek, Pleasant Valley and Pleasant Valley South basins. No existing sewer facilities are available for use in this portion of the site at this time.

Sewage from the campus site will be conveyed westerly in the Salmon Creek Interceptor to the County's Salmon Creek Sewage Treatment Plant (SCTP). The County is presently implementing a program to expand and upgrade the SCTP. Based on the flow projections presented below, it is anticipated that the County's program will stay ahead of the demands generated by the university.

### **Proposed System**

Like the water system, the sanitary sewer system is intended to provide service to the campus through phased development. The systems proposed to serve the campus are subject to the requirements of the Uniform Plumbing Code (UPC). The HDSD requires that the system capacity meet the guidelines provided in the UPC, and that a peaking factor of 3.0 be applied.



Based on the HDSD requirements, estimated flows for each of the identified three phases are as follows:

	Cumulated Flow by Phase - Gallons Per Minute		
	PHASE I (1998)	PHASE II (2010)	PHASE III (2025)
Average Daily Flow	65	105	210
Peak Flow	195	315	620

Phases I and II of campus development are located in the western portion of the campus site and will be served by a single point connection with the Mt. Vista Trunk. It is intended that the system extend into the site in a manner that will disturb the vegetated natural drainage courses as little as possible. It appears that the proposed gravity system will serve all proposed Phase I/II buildings. If isolated individual buildings are proposed outside the immediate vicinity of the Phase I/II core (i.e. motor pool), it is recommended that STEP systems be considered for service to minimize the potential disturbance to natural vegetation, wetlands, or steep slopes.

Phase III development is proposed for the east portion of the site. It is anticipated that a sewer trunk system will be extended up the Mill Creek corridor prior to the development of Phase III. However, HDSD has no plans for sewer extension in the near future. In the event that service is needed for Phase III development before extension of the HDSD system it would be possible to install a septic tank effluent pumping (STEP) system or conventional sewage pump station to serve the Phase III area.

#### **Cost Participation**

Washington State University will be responsible for all on-site sanitary sewer improvements. No off-site improvements are anticipated for Phase I and Phase II development. The type of trunk improvements that may be required for Phase III development are typically funded by HDSD.

## **STORM DRAINAGE**

### **Existing Conditions/Improvements**

The campus site is approximately 350 acres in size. The site is divided into east and west halves by Mill Creek. Mill Creek which runs from north to south passes under an existing bridge at N.E. Salmon Creek Avenue and joins Salmon Creek a short distance to the south. The terrain of the east half slopes gently to the west to the steep east bank of Mill Creek. The west half consists of gently sloping and rolling terrain in the upper portion near N.E. 29th Street. It then continues down a series of terraces to the west bank of Mill Creek. The upper areas of both the east and west halves of the campus site have been used for agriculture, and are vegetated primarily by pasture grass. The steeper slopes approaching Mill Creek are vegetated with a variety of evergreen and deciduous trees and undergrowth. Wetland occupy much of the lower portion of the site near Mill Creek.

Phases I and II of campus development are proposed for the upper portions of the west half of the site. With the exception of a small portion of the residential area west of the campus site, no off-site drainage enters this portion of the site. Phase III development will be concentrated on the easterly portion of the site. It is anticipated that any upstream off-site drainage will be directed to N.E. 50th Street. No significant off-site drainage is expected to pass through the proposed Phase III development.

There is presently an existing private road that runs along the north border of the campus site. This road crosses Mill Creek over a large corrugated metal plate culvert. The Phase III shows that this road as an up-graded developed connection between the east and west halves of the campus. Because of the potential impact on Mill Creek any proposed improvement of this private road will require careful consideration.

The close proximity of Salmon Creek and Mill Creek provide a convenient system for the discharge of drainage from the proposed campus. It appears that no off-site improvements will be required. However, due to concerns regarding water quality, downstream erosion, creek capacity and fisheries habitat, significant on-site measures will be necessary.

### **Proposed System**

Clark County stormwater management requirements are currently in a transition period. The standards for proposed improvements will likely be a combination of Puget Sound Surface Water Regulations, and King County, Washington Standards for Stormwater Management. According to Bob Blakemore of Clark County Public Works, a report being

prepared by Dr. Robert Horner, University of Washington, will greatly influence the approach to stormwater management for the proposed campus development.

It is intended that appropriate state-of-the art techniques be considered when developing the final approach to storm water management. Final system components may include retention/detention ponds and/or recharge systems to attenuate increased flows resulting from development. These systems may be designed to drain completely between storm events or to provide a wet pond environment to enhance runoff water quality characteristics. Other water quality considerations will include vegetated discharge swales and/or compost filtration. The final determination of system components will depend on the requirements of Clark County and the physical constraints of the site (i.e. soil erosiveness, soil permeability, etc.).

Because of the current uncertainty of Clark County's regulations, the proposed master drainage plan has incorporated techniques that have been acceptable to the County on recent development projects. The proposed collection system will include catch basins capable of trapping settleable solids (dirt and gravel) and floatables (oil and other floatable debris). Storm water will be conveyed in a system of pipes, and where possible vegetated swales to storm detention ponds. The vegetated swales will reduce flow velocities and will provide supplemental treatment in advance of the detention ponds. The detention ponds will maintain discharge rates from campus development to predevelopment rates for the 10-year 24 hour storm event. Detention ponds will be located in the flatter portions of the campus development area, above the natural drainage ways leading to Mill Creek. A suitable buffer will be maintained between the ponds and the natural drainage ways to allow discharge from the ponds to pass through a system of vegetated swales and wet ponds before entering the natural drainage way.

### **Cost Participation**

Washington State University will be responsible for all costs for on-site drainage facilities. No off-site improvements are anticipated.

## **SCHEDULES**

### **Design**

The design and construction of Phase I infrastructure improvements will include required water, sanitary sewer, and storm drainage improvements. It is anticipated that the design process for these improvements will take three to four months.

### **Review and Approval**

The following is a list of agencies that will likely be included in the review/approval process and an estimate of the review/approval period that will be required.

<b>SYSTEM</b>	<b>AGENCY</b>	<b>REVIEW/APPROVAL PERIOD</b>
Water	Clark County Public Utility District No. 1	1 Month
Sewer	Hazel Dell Sewer District	1 Month
Storm	Clark County Public Works	1 Month
	Washington Department of Ecology	1 Months
	Department of Fisheries	1-2 Months

### **Construction**

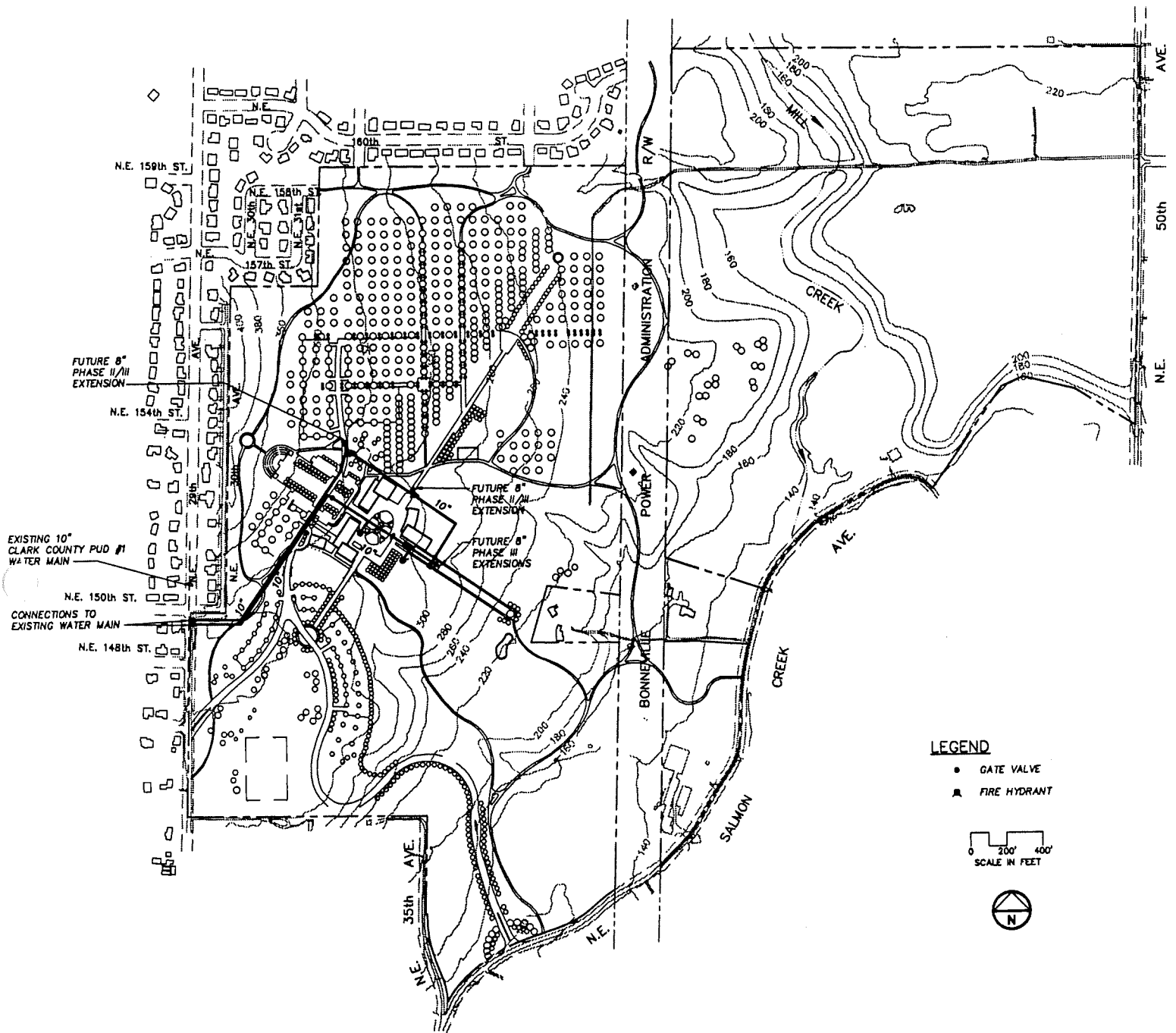
The required construction period can be affected significantly by the time of year in which construction is taking place. Assuming that construction takes place during the spring/summer/fall construction season, the required system improvements should be complete in 4-6 months.

**SERVICE AGENCIES AND CONTACTS**

**WATER**      **Clark County Public Utility District No.1 (PUD)**  
1615 NE 78th Street  
Vancouver, WA  
Contact:      Eric Beck, P.E.  
(206) 699-3347

**SEWER**      **Hazell Dell Sewer District (HDSD)**  
9514 NE Stutz  
Vancouver, WA  
Contact:      Warren Knuth  
(206) 573-3331

**DRAINAGE**      **Clark County Public Works**  
1408 Franklin  
Vancouver, WA  
Contact:      Warren Wannamaker  
                 Bob Blakemore  
(206) 699-2375



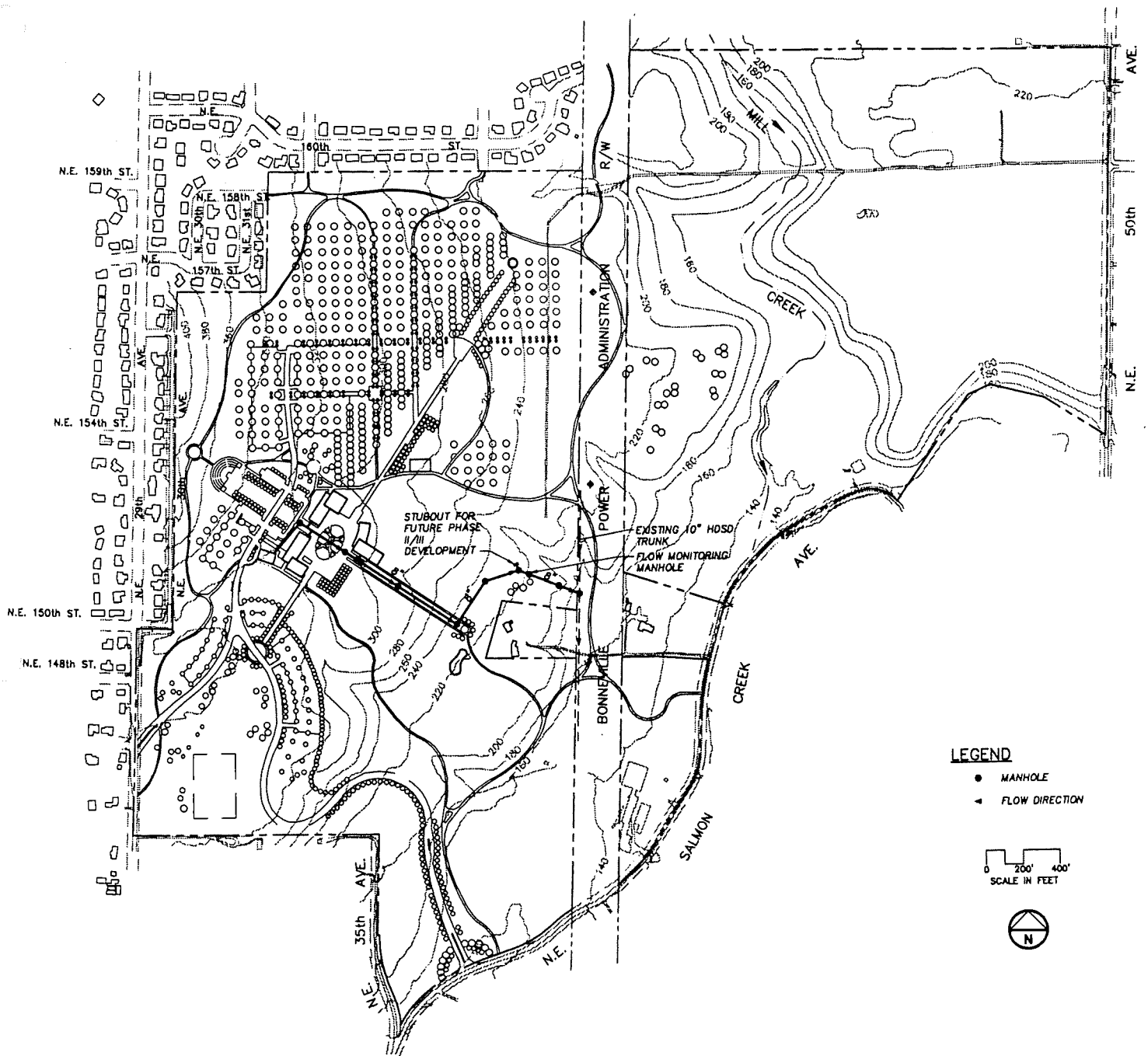
# PHASE I DEVELOPMENT WATER MASTER PLAN

JUNE 24, 1992

Parametrix, Inc.







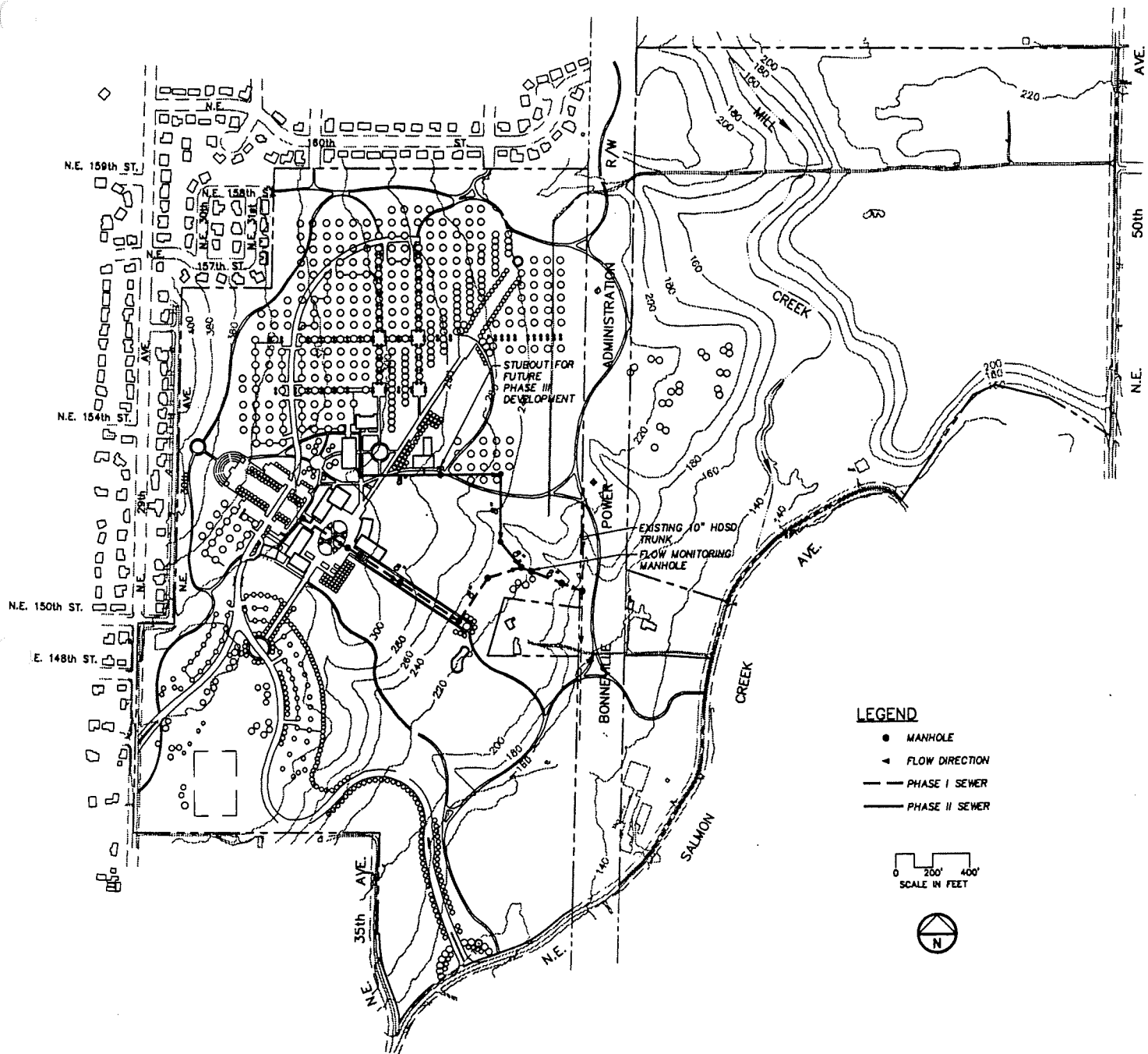
## PHASE I DEVELOPMENT MASTER SEWER PLAN

JUNE 24, 1992

Parametrix, Inc.







# LEGEND

- MANHOLE
- ▲ FLOW DIRECTION
- PHASE I SEWER
- - - PHASE II SEWER

0 200' 400'  
SCALE IN FEET

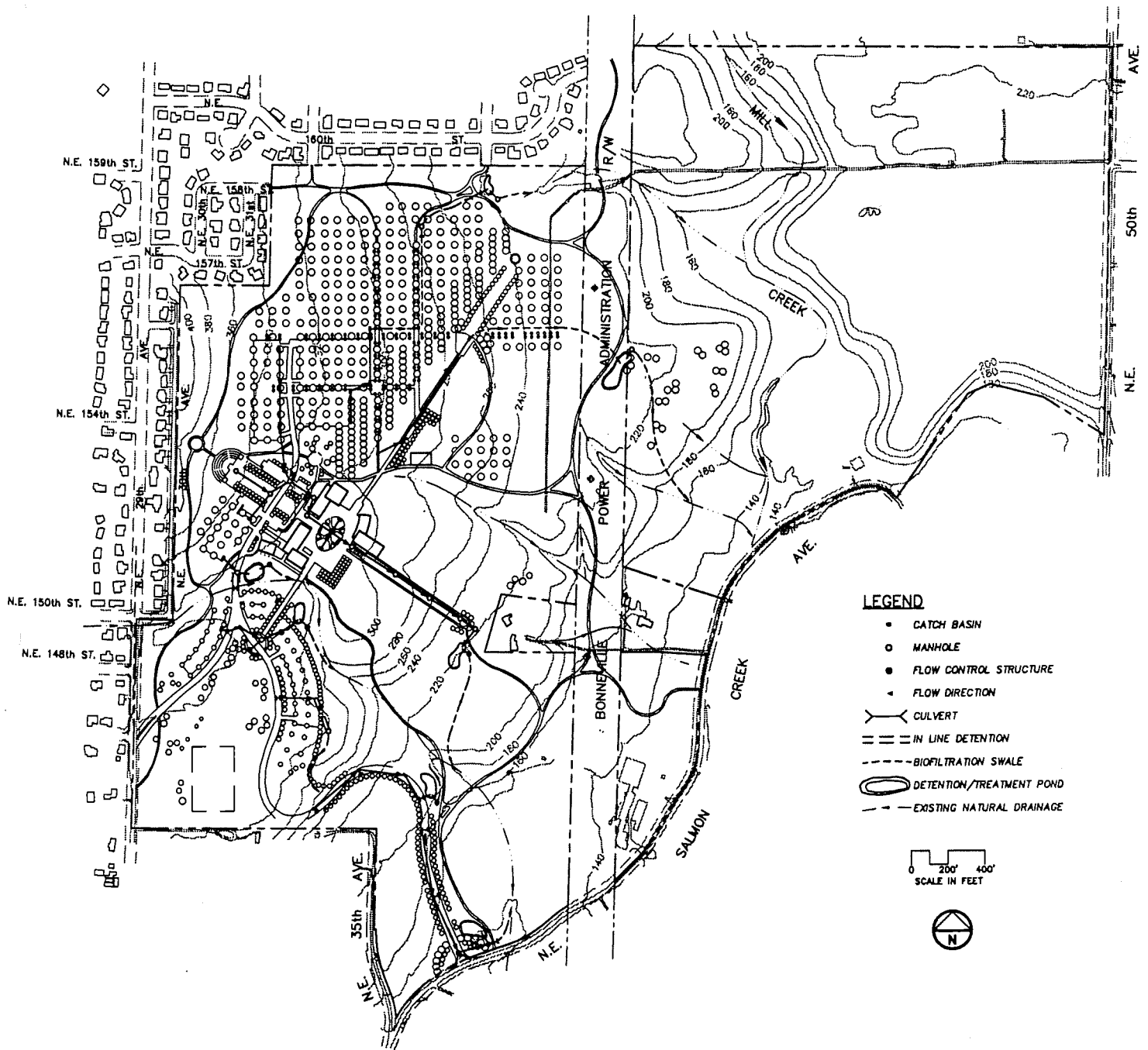


## PHASE II DEVELOPMENT MASTER SEWER PLAN

JUNE 24, 1992

Parametrix, Inc.



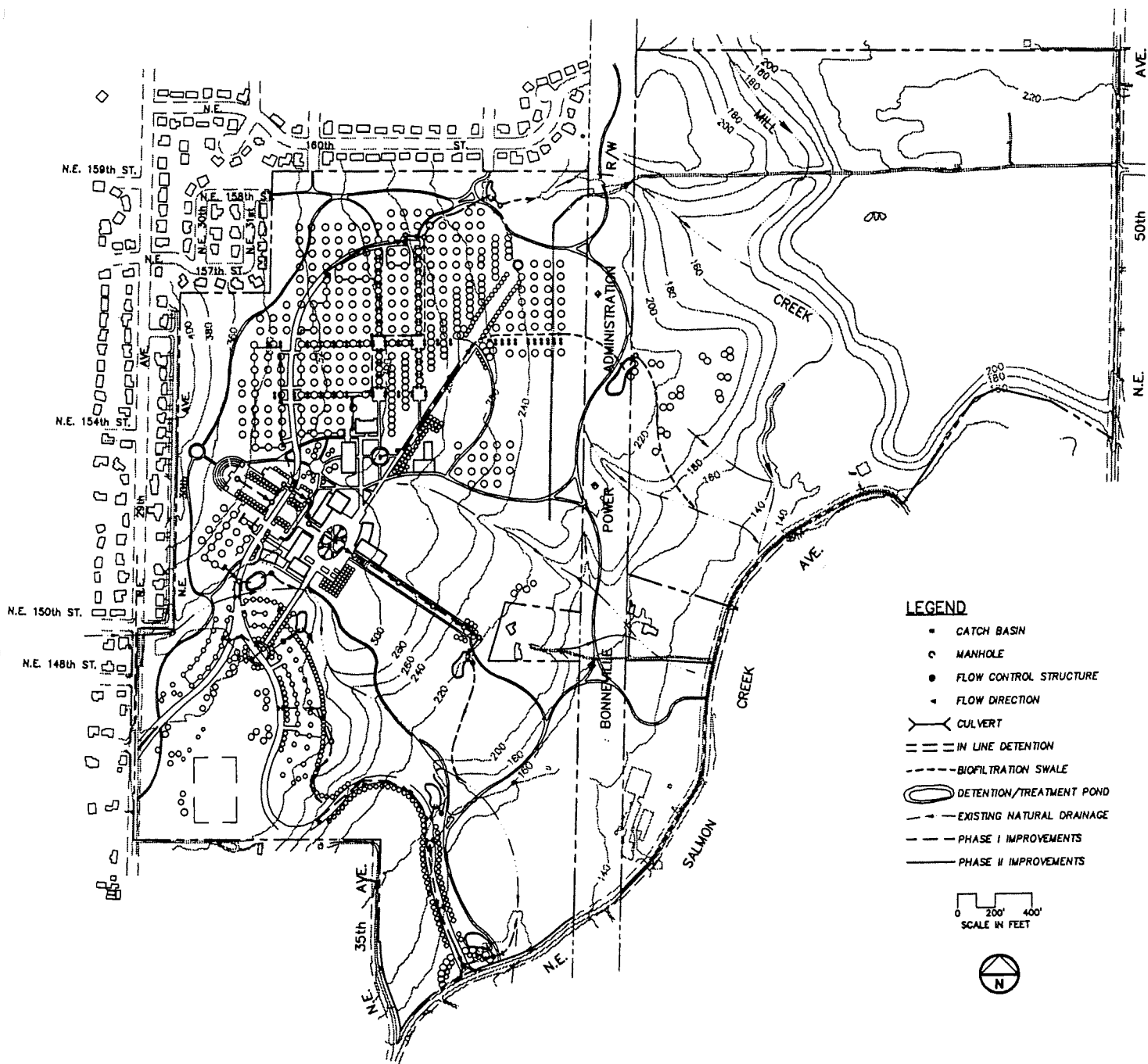


## PHASE I DEVELOPMENT DRAINAGE MASTER PLAN

JUNE 24, 1992

Parametrix, Inc.



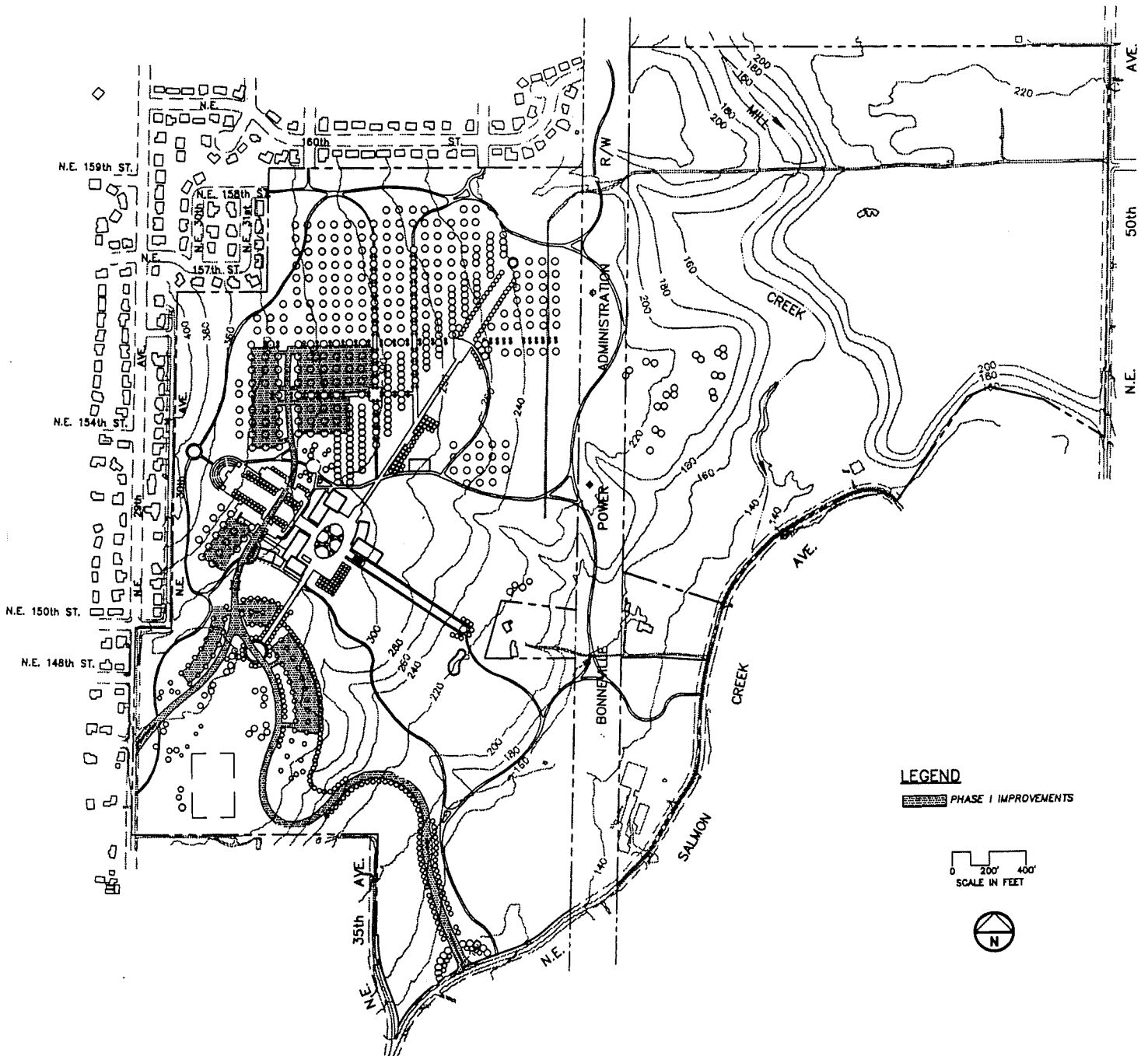


## PHASE II DEVELOPMENT DRAINAGE MASTER PLAN

JUNE 24, 1992

Parametrix, Inc.



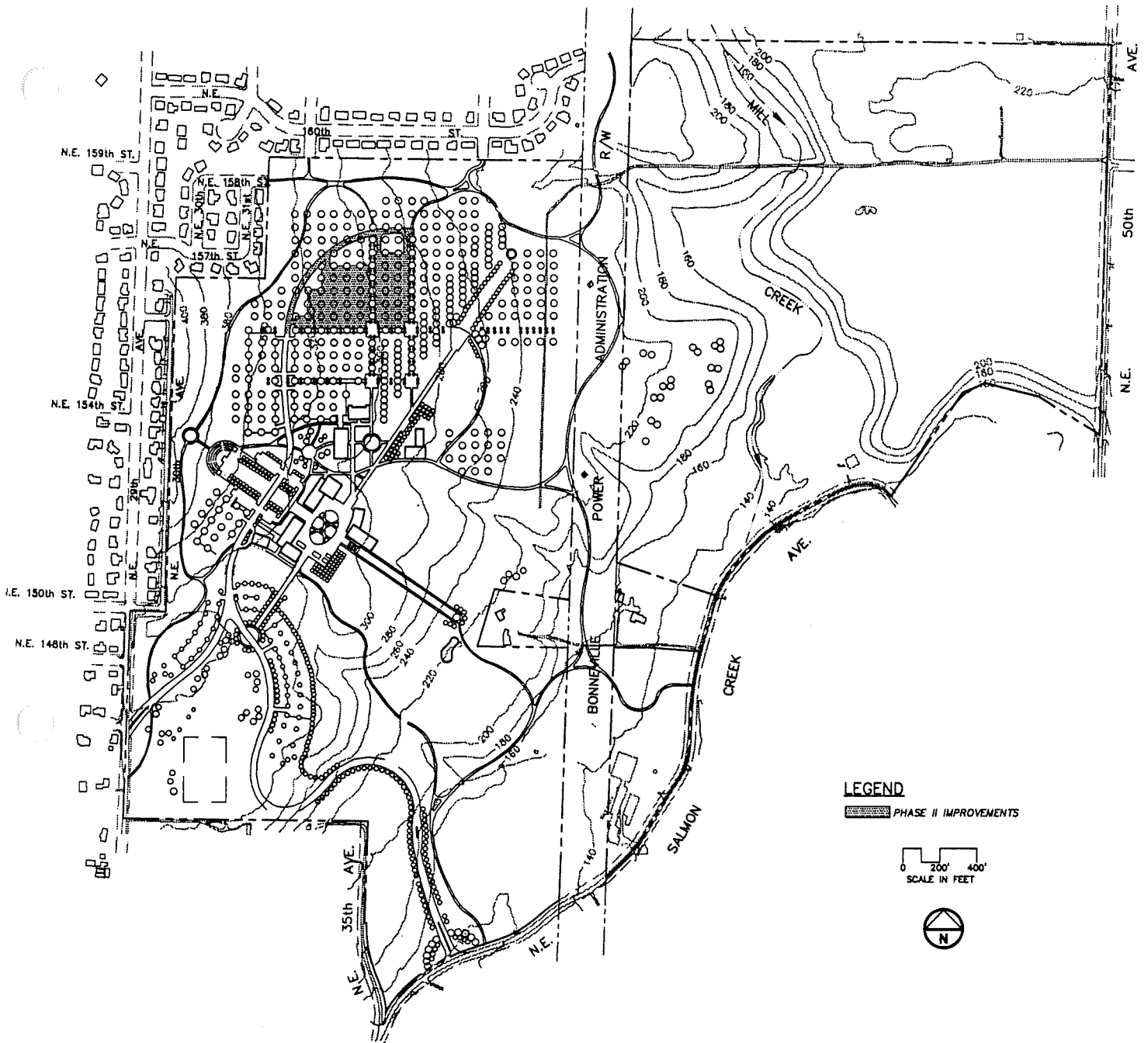


## PHASE I DEVELOPMENT ON-SITE ROADS & PARKING

JUNE 24, 1992

Parametrix, Inc.





## PHASE II DEVELOPMENT ON-SITE ROADS & PARKING

JUNE 24, 1992

Parametrix, Inc.



WSU VANCOUVER  
ELECTRICAL REPORT  
September 15, 1992

I SCOPE

- A. Determine the configuration of the primary electrical distribution, emergency generation and distribution, and provisions for campus voice/data/signal systems to satisfy the requirements of the planned campus facilities in the most reliable and cost efficient method possible.
- B. Provide an infrastructure of electrical systems which are inherently flexible and can allow campus modifications, program changes, and advances in equipment and systems technology to be implemented in an efficient manner.

II RECOMMENDATIONS

- A. Electrical Service Rate Schedule: Clark Public Utility is currently undergoing rate revisions, and currently does not have a schedule directly applicable to a campus facility. Recommended approach is to meet with CPU and develop a rate schedule to serve the needs of WSU.
- B. Electrical Distribution System: Provide primary switchgear in the central plant building and extend a multiple loop distribution system to serve groups of campus buildings. Provide pad mounted, fusible switches to serve individual building transformers.
- C. Emergency Power: Provide a central plant generator with required switchgear, load bank, and controls to allow for paralleling multiple machines. Install emergency feeders to automatic transfer switches located in each major building.
- D. Communications Provisions: Provide a system of underground raceways to interconnect the campus buildings, utilizing a manhole/concrete encased ductbank system installed along the two major pedestrian corridors as the spine of the system. Raceways from the communications terminal closet in each building would terminate at the nearest manhole to connect the campus buildings to the spine.
- E. Site Lighting: Provide pole mounted, cut off type high pressure sodium luminaires at 25'-30' mounting height along streets and roadways with matching type luminaires mounted at 10'-12' in parking areas.

Provide decorative pole mounted luminaires and low level bollards along pedestrian corridors supplemented with ground tree lights for special effect.

### III APPROACHES

- A. In analyzing various system approaches, the extent of the current master plan development of the building did not allow precise calculations of loads or equipment usages. Therefore, calculations have been made based upon various assumptions as stated in the calculation portion and our past experience for this facility type. The loads are sufficient for comparative purposes, but should not be taken as actual loads.
- B. Cost estimates were made using actual costs received from vendors and cost estimating guides such as the latest edition of Means and our own experience in construction costs.
- C. Life cycle cost analysis was made using initial first cost items, maintenance, energy cost with inflation, interest and future additional capital and replacement costs amortised to current costs, and summarized. Summary costs were used to compare system results.
- D. In system comparisons, advantages and disadvantages have been provided for performance evaluations. Systems have been costed to provide comparable performances, that is, if the central plant approach provides standby, than the decentral plant approach was costed with comparable standby provisions.
- E. A comparison was made providing all utilities in a single tunnel verses the separate installation for electrical utilities and chilled water supply and return piping. Results are included in the mechanical section of this report.

### IV ELECTRICAL SERVICE

- A. Electrical service to the WSU Campus will be by Clark County Public Utility District, referred to as Clark Public Utilities (CPU). Service to the campus will be 12470Y/7200V, 3 phase, 60 Hertz via overhead lines routed adjacent to 159th Street from the Manor #2 substation at N.E. 159th and 50th Avenue. It is anticipated a second service will be available from a future 12.5 KV line to be installed at the south end of the campus as the area is developed.

CPU has two published delivery rate schedules which apply to WSU, schedule 34 and schedule 83. Schedule 83 will soon be phased out and replaced by a new schedule 85.

The exact criteria of schedule 85 is not available at the time of this report, however preliminary studies indicate it would not be advantageous for WSU to apply for this schedule. CPU has expressed a desire to meet with WSU in the near future to review the options which will be available to WSU at the time of campus energization. Additionally, CPU has indicated that another schedule may be developed specifically for campus type customers. A brief description of the schedules is presented to establish the parameters which determine the projected cost of service.

1. Schedule 85 (Proposed): Developed for industrial users, CPU furnishes service at primary voltages through one meter at a single point of delivery. The customer is responsible for providing and maintaining all transformers and distribution equipment beyond the point of service. The applicable customer, energy, demand, and power factor charges are summarized in Table 1: Rate Schedule Comparison.

Advantages:

- Energy charge, at .01775 \$/KWh is the lowest available.
- The single meter configuration allows full diversity between buildings, ensuring the minimum possible demand load.
- Building access would not be required by CPU for all campus buildings to record meter readings since only a single remote meter would be used.

Disadvantages:

- Demand charge, at 4.40 \$/Kw, is significantly higher than schedule 34.
  - The capital cost of providing and maintaining the distribution system is considerable.
  - CPU reserves the right to restrict the availability of this schedule to customers with high load factors and have indicated that WSU may not qualify for consideration.
2. Schedule 34: Primarily for single building users or multiple buildings in close proximity, the schedule contains options for primary metering the entire campus, or secondary metering at each building. The rate structure is identical for both options of schedule 34 and is summarized in Table 1.



3. Schedule 34 Primary metering: CPU furnishes service at primary voltages through one meter at a single point of delivery as well as the first bank of service transformers. The customer assumes responsibility for the remaining transformers and distribution system for service to additional campus points of service.

Advantages:

- Single meter for entire campus. CPU has no requirement for building access.
- Minimizes demand rates by allowing diversity between the buildings.
- WSU retains flexibility to design primary distribution system in a manner most suited to the campus needs.

Disadvantages:

- WSU responsible for installation and maintenance of primary distribution system beyond the first bank of transformers.

4. Schedule 34 Secondary metering: CPU furnishes service to each building on campus and meters each individually on the secondary side of the building transformer. CPU also assumes responsibility for all distribution equipment installation and maintenance.

Advantages:

- CPU bears all costs for installing and maintaining system up to and including all pad mounted transformers.

Disadvantages:

- Individual meters at each building. Customer responsible for allowing CPU access to meters at all times.
- Each meter subject to individual meter charges and maximum building demand.
- Power delivered at highest energy rate under Schedule 34.
- CPU will determine configuration of primary distribution system with little input from WSU.

5. Preliminary Future Campus Rate Schedule: The existing schedules do not lend themselves to application for a customer with multiple buildings spread over a large campus. Additionally, the load factor for a campus is generally low due to the high percentage of low use time during evenings and over weekends. To address these issues, CPU has expressed an interest in developing a rate schedule designed for campus facilities where service would be furnished in a manner which takes into account the unique features of an academic campus.

Since the schedule is not yet implemented, the potential rate schedule cost cannot be evaluated, although CPU has indicated that the schedule would be at least as favorable as the existing schedules.

6. Billing Cost Comparisons:

- a. Calculation of billing costs for schedules 34 and 85 requires input based on the expected electrical load usage for each building. These values are compiled in Table 2: Electrical Load Estimate as a function of watts per square foot. The required energy and demand totals for each building are then calculated as indicated in Table 3: Metering Calculations. The demand is calculated by applying to the total load a diversity factor based on the building occupancy and intended use. The energy usage is determined by applying an operating demand factor to the building load which represents the expected constant usage for both day and night/weekend periods.
- b. Schedule 34 billing cost: Table 4.
- c. Schedule 85 billing cost: Table 5.

- B. RECOMMENDATIONS: Clark Public Utilities is presently undergoing rate revisions and recognizes that college campuses do not fall within a presently established favorable rate schedule. The size of the campus with multiple buildings makes the Schedule 34 rate unattractive, but it appears WSU will not have the new schedule 85 as an option because of the low utilization factor caused by low usage at night and weekends inherent with this type of facility. CPU has expressed a desire to work with WSU directly, present various delivery options and equipment lease options available along with projected rate options. Regardless of the system and rate structure chosen, the completed installation will require an underground primary distribution system with capabilities to serve pad mounted transformers connected in a loop configuration.

## V DISTRIBUTION SYSTEMS

- A. It is understood the campus electrical distribution systems will be underground. The only exception to this is the initial primary feed to the campus by the Clark Public Utilities' overhead line. It does not appear this line will infringe upon WSU property.
- B. The primary power to the building pad mounted transformers will be through a concrete encased underground ductbank arrangement with manholes spaced along the ductbank route at key locations to serve as splicing and pull locations for the primary cables. No switching equipment will be located in the manholes. The ductbank/manhole system will be routed under the mall spine of the campus parallel with the emergency electrical distribution and communication ductbanks. Actual location of the manhole/ductbank systems will recognize the location of sidewalks, malls, building appurtenance, etc., to have minimal impact on the overall campus esthetics while retaining access capabilities for maintenance and expansion. It is proposed the ductbank system will have the capacity to serve the entire campus utilizing any combination of single loop, multiple loop or radial distribution configurations. The options are as described below:
- C. Single Loop System: System consists of a single loop configuration of 15KV cable of large enough capacity to serve the entire campus emanating from the 15KV distribution switchgear in the central plant. System would initially require a minimum of two 15KV switches in the central plant to serve the loop. The loop would have pad mounted switching cubicles at locations where transformer taps are to be made. The cubicles would consist of two loop isolation switches plus the quantity of tap switches appropriate for the location.

### Advantages:

- Ability to isolate primary faults, thus reducing outages.
- Individual building transformers may be easily isolated from the system for maintenance, testing, or replacement.

### Disadvantages:

- Primary cables must have capacity for entire campus load.

- D. Multiple Loop Systems: System consists of multiple loop configuration serving clusters of buildings with loops emanating from the 15KV distribution center in the central plant. System would require the initial 15KV campus disconnect switch plus two 15KV switches in the central plant for each loop. System would use similar configuration for serving individual buildings as the single loop system.

Advantages:

- Ability to isolate primary faults, thus reducing outages.
- Individual building transformers may be easily isolated from the system for maintenance, testing, or replacement.
- Most reliable overall in that no single loop carries the entire campus load.
- Primary cable capacity is reduced to carry only the building loads on the loop.

Disadvantages:

- The amount of primary cable required is increased to establish multiple loops.
- Requires two switches in the central plant switchgear lineup for each loop.

- E. Radial System: System would consist of individual 15KV switches located in the central plant for each pad mount transformer. Individual feeders would be installed for each transformer.

Advantages:

- Pad mounted switches at each transformer location are not required.
- Capacity of primary cables are reduced to carry only a single building load.

Disadvantages:

- Primary fault causes outage to buildings on the affected radial until the fault can be located and corrected.

- F. Recommendations: Make provisions in central plant for the multiple loop system. Install required campus disconnect and 15KV switches for a loop system serving the Phase 1 buildings.

It is recommended additional switches be installed in the central plant 15KV switchgear line-up to serve the central plant transformers as a single loop system rather than utilizing the pad mount equipment at that location.

## VI EMERGENCY POWER

- A. Emergency power will be required at each building to supply power to egress lighting, elevators, and other essential loads in the event of loss of commercial service. The power will be provided at 480Y/277V from diesel fueled engine driven generators. Each building will be provided with a transfer switch to initiate generator start up and automatic switching of the essential loads to the emergency source.

As shown in Table 2, the projected emergency load is relatively light, averaging, 40-50 KW per building with a total anticipated campus load of under 500 KW.

The use of natural gas as a fuel source for the generators was not considered. Since the code requirement for on-site storage of fuel disqualifies a utility source, and would be extremely difficult to meet.

Two alternatives were reviewed with regard to the configuration of the emergency generation and distribution system. The first option utilizes a single point of generation in a central plant and the second option involves providing a separate generator for each building.

1. Single point of generation: Space would be developed in the central plant building to house two 500 KW generators and the main emergency distribution panel. Initially, only one generator would be required to handle the campus load. The second generator would only be required in the event of sustained growth of the emergency loads. Feeders from the central plant to an automatic transfer switch in each building would be via a manhole/ductbank distribution system with stub outs at each building.

### Advantages:

- Consolidation of maintenance, fuel handling, and generator exercising tasks to a single point on campus. Access to buildings by maintenance personnel would not be required to service the equipment or perform load testing.

- Future emergency load growth could be easily handled in the central plant by utilizing the full capacity of the first generator and then installing a second generator when required.
- The amount of space in each building required for the emergency system is minimized. Each building will require only a transfer switch and branch panelboard.
- Peak shaving strategies can be easily implemented to reduce demand on the utility system.

Disadvantages:

- A failure of the central plant generator would leave the entire campus without emergency power until repairs could be completed or a temporary generator connected.
- The control system required for a central plant system is very sophisticated, requiring paralleling equipment for multiple generators and load bank equipment.

2. Separate generators for each building: Space would be required in each building to house a generator dedicated to serving the respective building. Each building would be completely isolated and independent from the remainder of the campus. The status of each transfer switch would be displayed at the central plant to allow remote monitoring of each building.

Advantages:

- Most reliable in that failure of any single generator would only affect the building it serves and not the entire campus.
- The control scheme is relatively simple since each generator would be started by only one transfer switch.

Disadvantages:

- Space would be required in each building dedicated to housing the generators and handling engine exhaust, combustion and cooling air, and fuel storage and transfer equipment.
- Maintenance, fuel handling, and generator exercising tasks would be required at each building at regular intervals.

3. Life Cycle Cost Analysis: The two alternatives are compared in Table 7: Emergency Power System Life Cycle Cost Comparison, with the following parameters used for input.

- First Cost: The initial installation costs as calculated in Table 8: Central Plant Generation Construction Estimate and Table 9: Individual Building Generation Construction Estimate. The construction estimates are itemized according to the pertinent materials and equipment required for Phase I and II construction. The accumulated costs are then projected for a 1998 dollar cost to correspond with the life cycle analysis time frame. For the purposes of the study, Phase I is projected for construction in 1998 and Phase II is assumed to occur in 2010.
- Annual Fuel Cost: Calculation assumes the generator plant will be exercised weekly for an average one hour duration. This factor also accounts for expected operation during commercial service outages. The costs for the central plant and individual generators are calculated as follows:

Annual fuel cost (\$) = (diesel cost)x(diesel consumption per hr)x(annual hours of operation)

Central Plant

Number of generators = 1

Diesel cost = 1.20/gal

Diesel consumption = 36 gal/hr

Annual operation = 52 hrs

Annual fuel cost:

$$\begin{aligned}\text{Phase I \& II} &= (1.20) (36) (52) = \$2,246 \text{ (1992)} \\ &= \underline{\$2,841 \text{ (1998) }}\end{aligned}$$

Individual Building Generators

Number of generators = 4 (phase I),  
6 (phase II)

Diesel cost = \$1.20/gal

Diesel consumption = 4 gal/hr each generator

Annual operation = 52 hrs per generator

Annual fuel cost:

$$\begin{aligned}\text{Phase I} &= (1.20) (4) (4) (52) = \$ 998 \text{ (1992)} \\ &= \underline{\$1,262 \text{ (1998) }}\end{aligned}$$

$$\begin{aligned}\text{Phase II} &= (1.20) (4) (6) (52) = \$1,497 \text{ (1992)} \\ &= \underline{\$3,032 \text{ (2010) }}\end{aligned}$$

Note that the annual cost is extended to 1998 and beyond using a 4% inflation factor.

- Annual Maintenance Cost: Reflects cost of required semi-annual maintenance and safety inspections as well as the manpower required to execute the weekly generator exercises.

Annual maintenance cost is determined as follows: Annual Maint = (annual inspection)+(weekly test)x(52 weeks)

#### Central Plant

Number of generators = 1

Annual inspection = \$800

Weekly test = (1 man-hour) (50\$/man-hour) = \$50

Annual Maint:

$$\begin{aligned}\text{Phase I \& II} &= (\$800) + (\$50) (52) \\ &= \$3,400 \text{ (1992)} \\ &= \underline{\$4,302 \text{ (1998)}}$$

#### Individual Building Generators

Number of generators = 4 (phase 1),  
6 (phase II)

Annual inspection = \$500 each generator

Weekly test = (3/4 man-hour) (50\$/man-hour)  
= \$37.50/wk each generator

Annual Maint:

$$\begin{aligned}\text{Phase I} &= (\$500) (4) + (\$37.50) (4) (52) \\ &= \$9,800 \text{ (1992)} \\ &= \$12,400 \text{ (1998)}\end{aligned}$$

$$\begin{aligned}\text{Phase II} &= (\$500) (6) + (\$37.50) (6) (52) \\ &= \$14,700 \text{ (1992)} \\ &= \underline{\$29,779 \text{ (2010)}}$$

The life cycle cost comparison projects these costs through the year 2025 using 4% inflation and 8% interest. As indicated, the net 1998 cost for the central plant option is approximately 432,500, compared to 486,461 for the individual building generator option.

4. Recommendations: Develop space in the central plant building to house a single point of emergency generation for the entire campus, including room to add generating capacity and paralleling equipment. Install underground distribution from the central plant to transfer switches in each building. Provide system control such that transfer switches have generator start capability. Also, arrangements should be made in advance with local vendors to supply a temporary generator which could be rapidly procured and connected in the event of generator failure.



## VII COMMUNICATIONS PROVISIONS

- A. An underground system of raceways will be provided to facilitate distribution of the campus voice, data and low voltage signal systems among buildings. The general configuration of the raceway system will utilize a major "spine" along the major axis of the phase I development with radials to each building and capped stub-outs dedicated to the phase II and III developments. The system will be extended to N.E. 29th Avenue under phase I to obtain telephone service. Service may be extended to the north when the phone company or other communications agency provides lines to the north of the campus.

Two alternatives were considered to accomplish the communications provisions. Option 1 utilizes a manufactured trench assembly for the spine of the system raceway in conjunction with the emergency power distribution and Option 2 considers a six cell ductbank system.

1. **Manufactured Trench:** A utility trench would be installed along the pedestrian corridor from the utility building to the southwest end of the campus. Provisions for extension of the trench along the phase II development axis would be installed at the intersection of the pedestrian corridor near central campus. Phase I service conduits would be extended from the end of the trench to N.E 29th. Two 4-inch conduits with innerduct would be routed from the communications terminal location in each building to the utility trench. Stub-outs would be provided at each building communications terminal location for purposes of interconnecting adjacent buildings without routing through the manhole system.

### Advantages:

- The trench allows access at any point along its length via the lift off cover for cable installation and maintenance.
- Trench allows maximum capacity for system cables.
- The emergency distribution system could be routed within the trench to consolidate installation costs should the central plant emergency generation option be chosen.

Disadvantages:

- Installed cost, at \$124 per linear foot is considerably higher than a ductbank/manhole system.
- Trench must be installed adjacent to pedestrian paths and has an exposed surface which may present a landscape appearance problem, particularly at slopes.

2. Ductbank System: Manhole/concrete encased ductbank system would be routed through the spine of the campus, installed adjacent to the 15KV system and the emergency power system previously described. The proposed system generally would include manholes placed adjacent to the other manholes with a six cell ductbank connecting the communication manholes. Two 4-inch PVC conduits will be routed from the communications terminal location in each building to the nearest manhole. As with the utility trench option, inner ducts would be utilized in the 4-inch building service and ductbank conduits to provide system separation along with maximum utilization of the ductbank and building conduits.

Advantages:

- Installed cost of a ductbank/manhole system, at \$37 per linear foot is lowest among options.
- Ducts would be buried, leaving only manhole covers as exposed elements of the system.

Disadvantages:

- Access to the system cables would be available only at manhole or pullbox locations.
- Capacity for system cables would be limited to the capacity of the six 4-inch conduits.

- B. Recommendations: Install ductbank/manhole system as provisions for communications system. As the communications cabling information comes available during design phase, the cell configuration of the ductbank could be expanded as required.

## VIII SITE LIGHTING

- A. Site lighting is not shown on the drawings due to the early phase of the design and flexibility which must be maintained in the master planning phase. An explanation of the proposed lighting scheme follows, which still leaves the actual design and layout flexible enough to allow for specific layouts for specific locations.
- B. In general, the exterior lighting will be high pressure sodium, consistent with current practices, utilizing the most energy efficient system available with today's light sources. Basic systems will be as follows:
1. Street and Roadway: 400 watt "shoe box" cut-off luminaires on 25' to 30' poles. Lights will be controlled by individually mounted photocells on a dusk to dawn basis. Poles will be placed on 100 ft. to 150 ft. spacings to allow for recommended light levels and uniformity ratios, recognizing street curves elevation changes, trees, etc.
  2. Parking Areas: Matching "shoe box" luminaires on 15' to 25' poles depending upon lot configurations.
  3. Mall and Walk: Combination of matching "shoe box" luminaires on 12' to 20' poles, decorative pole luminaires and low level bollards appropriate for specific sites.
  4. Special Effects: In ground tree lights, selected decorative specific for the location.
- C. Allowance has been made in the Phase 1 budget for the following site lighting units.

400W HPS - 30' Pole	12	ea	2,010.00	24,120
150W HPS - 20' Pole	20	ea	1,460.00	29,200
100W HPS - 12' Pole	20	ea	1,320.00	26,400
70W HPS Bollard	15	ea	850.00	12,750
U.G. Wiring	5000	ft	9.50	<u>47,500</u>
<u>Total</u>				<u>\$139,970</u>

JPG/cme  
6851/rpts.

**PAE Consulting Engineers**

Project: WSU - Vancouver Campus  
 Job No.: 6851  
 Calc By: JPG

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Charge	Monthly Cost	
	Schedule 34	Schedule 85
Customer Charge (\$/mo)	28.00	63.25
Energy Charge (\$/kwh): All Months	0.0218	
Sep - Mar		0.0195
Apr - Aug		0.0153
Demand Charge (\$/kw): All Months		4.40
Dec - Apr	3.56	
May - Nov	1.95	

Monthly Cost Comparison				
Month	Energy in \$/KWH		Demand in \$/kw	
	Sched 34	Sched 85	Sched 34	Sched 85
Jan	0.0128	0.0195	3.56	4.40
Feb	0.0128	0.0195	3.56	4.40
Mar	0.0128	0.0195	3.56	4.40
Apr	0.0128	0.0153	3.56	4.40
May	0.0128	0.0153	1.95	4.40
Jun	0.0128	0.0153	1.95	4.40
Jul	0.0128	0.0153	1.95	4.40
Aug	0.0128	0.0153	1.95	4.40
Sep	0.0128	0.0195	1.95	4.40
Oct	0.0128	0.0195	1.95	4.40
Nov	0.0128	0.0195	1.95	4.40
Dec	0.0128	0.0195	3.56	4.40
<b>Average</b>	<b>0.0128</b>	<b>0.01775</b>	<b>2.62</b>	<b>4.40</b>

**Table 1: Rate Schedule Comparison**

**PAE Consulting Engineers**

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Building Number	Load Description	Bldg sf	Watts/ sf	Kilowatt Load		
				Normal	Emerg	Total
Bldg 1	Lighting/Power	74612	4.25	317		317
	Mech Equipment		5.00	373		373
	Life Safety Ltg		0.15		11	11
	Elevator				30	30
Subtotal.....			9.80	690	41	731
Bldg 2	Lighting/Power	63080	3.00	189		189
	Mech Equipment		5.00	315		315
	Life Safety Ltg		0.15		9	9
	Elevator				30	30
Subtotal.....			8.63	505	39	544
Bldg 3	Lighting/Power	70630	5.50	388		388
	Mech Equipment		6.00	424		424
	Life Safety Ltg		0.15		11	11
	Elevator				30	30
Subtotal.....			12.07	812	41	853
Bldg 4	Lighting/Power	9690	3.25	31		31
	Mech Equipment		5.00	48		48
	Life Safety Ltg		0.15		1	1
	Elevator				1	1
Subtotal.....			8.40	80	1	81
Bldg 5	Lighting/Power	21550	4.00	86		86
	Mech Equipment		5.00	108		108
	Life Safety Ltg		0.20		4	4
	Cent Plant Equip			2500	50	2550
Subtotal.....			127.53	2694	54	2748
PHASE I TOTALS		239562		4781	177	4958
Bldg 5/6	Lighting/Power	37927	4.00	152		152
	Mech Equipment		5.00	190		190
	Life Safety Ltg		0.20		8	8
	Cent Plant Equip			1500	50	1550
Subtotal.....			50.07	1841	58	1899
Bldgs 7/8	Lighting/Power	104546	4.25	444		444
	Mech Equipment		5.00	523		523
	Life Safety Ltg		0.15		30	30
	Elevator				60	60
Subtotal.....			10.11	967	90	1057
PHASE II TOTALS		142473		2808	148	2956
CAMPUS TOTALS		382035		7589	325	7914

**Table 2: Electrical Load Estimate**

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Phase	Bldg. No.	Sq.Ft.	Calc Watts/SF	Calc Demand		Operating Demand		Energy KWh	
				Factor	KW Load	Normal	Night	360Hr/Mo	Total/Mo
1	1	74612	9.80	0.65	475	0.6	0.1	157972	26329
1	2	63080	8.63	0.65	354	0.6	0.1	117526	19588
1	3	70630	12.07	0.75	640	0.7	0.2	214916	61404
1	4	9690	8.40	0.65	53	0.5	0.1	14651	2930
1	5	21550	127.53	0.75	2061	0.6	0.3	593624	296812
2	5/6	37927	50.07	0.65	1234	0.6	0.3	410169	205084
2	7/8	104546	10.11	0.60	634	0.5	0.1	190269	38054
									228323

Table 3: Metering Calculations

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 Calc By: JPG  
 Costs in 1992 Dollars

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**Table 4 - Schedule 34**

Phase	Bldg	Calc Bldg Load		\$ Cost		\$ Cost	
		Demand KW	Energy KWH	Demand*	Energy**	Monthly Total	Annual Total
1	1	475	184301	1245	4018	5263	63159
1	2	354	137114	927	2989	3916	46988
1	3	640	276320	1676	6024	7700	92395
1	4	53	17582	139	383	522	6263
1	5	2061	890436	5400	19412	24812	297742
2	5/6	1234	615253	3234	13413	16646	199757
2	7/8	634	228323	1662	4977	6639	79669
Total.....						65498	785973

\*Demand Cost = \$2.62/KW (Ave). See Table 1

\*\*Energy Cost = \$0.0218/KWH. See Table 1

**Table 5 - Schedule 85**

Phase	Bldg	Calc Bldg Load		\$ Cost		\$ Cost	
		Demand Diversity	Demand KW	Demand*	Energy**	Monthly Total	Annual Total
1	1	0.90	428	1883	3271	5154	61846
1	2	0.85	301	1323	2434	3756	45078
1	3	0.80	512	2251	4905	7156	85874
1	4	0.78	41	182	312	494	5924
1	5	0.75	1546	6802	15805	22607	271286
2	5/6	0.68	839	3693	10921	14614	175365
2	7/8	0.65	412	1814	4053	5867	70400
Total.....						59648	715773

\*Demand Cost = \$4.40/KW. See Table 1

\*\*Energy Cost = \$0.01775/KWH (Ave). See Table 1

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Interest = 8%  
 Inflation = 4%

**RATE SCHEDULE COST COMPARISON**

YEAR	SCHED 34	SCHED 85
YR-1998	\$994,507	\$905,681
YR-1999	\$1,034,287	\$941,908
YR-2000	\$1,075,659	\$979,585
YR-2001	\$1,118,685	\$1,018,768
YR-2002	\$1,163,433	\$1,059,519
YR-2003	\$1,209,970	\$1,101,899
YR-2004	\$1,258,369	\$1,145,975
YR-2005	\$1,308,704	\$1,191,814
YR-2006	\$1,361,052	\$1,239,487
YR-2007	\$1,415,494	\$1,289,067
YR-2008	\$1,472,114	\$1,340,629
YR-2009	\$1,530,998	\$1,394,254
YR-2010	\$2,031,712	\$2,332,954
YR-2011	\$2,112,980	\$2,426,272
YR-2012	\$2,197,499	\$2,523,323
YR-2013	\$2,285,399	\$2,624,256
YR-2014	\$2,376,815	\$2,729,226
YR-2015	\$2,471,888	\$2,838,395
YR-2016	\$2,570,764	\$2,951,931
YR-2017	\$2,673,594	\$3,070,008
YR-2018	\$2,780,538	\$3,192,808
YR-2019	\$2,891,759	\$3,320,521
YR-2020	\$3,007,430	\$3,453,341
YR-2021	\$3,127,727	\$3,591,475
YR-2022	\$3,252,836	\$3,735,134
YR-2023	\$3,382,949	\$3,884,540
YR-2024	\$3,518,267	\$4,039,921
YR-2025	\$3,658,998	\$4,201,518

**Table 6: Utility Schedule Cost Comparison**



**PAE Consulting Engineers**

Project: WSU - Vancouver Campus

Job No.: 6851

Calc BY: JPG

INTEREST - 8%

INFLATION - 4%

Page: 1 of 1

Date: 9/4/92

	CENTRAL PLANT GENERATOR				INDIVIDUAL BLDG GENERATORS			
	FIRST COST	ANNUAL FUEL COST	ANNUAL MAINTENANCE COST	1998 DOLLAR COST	FIRST COST	ANNUAL FUEL COST	ANNUAL MAINTENANCE COST	1998 DOLLAR COST
<b>NET 1998 COST</b>	<b>\$310,794</b>			<b>\$432,648</b>	<b>NET 1998 COST</b>			<b>\$486,461</b>
YR-1998		\$2,841	\$4,302	\$317,408		\$1,262	\$12,400	\$195,418
YR-1999		\$2,955	\$4,474	\$6,369		\$1,312	\$12,896	\$12,181
YR-2000		\$3,073	\$4,653	\$6,133		\$1,365	\$13,412	\$11,730
YR-2001		\$3,196	\$4,839	\$5,906		\$1,420	\$13,948	\$11,296
YR-2002		\$3,324	\$5,033	\$5,687		\$1,476	\$14,506	\$10,877
YR-2003		\$3,457	\$5,234	\$5,477		\$1,535	\$15,086	\$10,475
YR-2004		\$3,595	\$5,443	\$5,274		\$1,597	\$15,690	\$10,087
YR-2005		\$3,739	\$5,661	\$5,078		\$1,661	\$16,318	\$9,713
YR-2006		\$3,888	\$5,888	\$4,890		\$1,727	\$16,970	\$9,353
YR-2007		\$4,044	\$6,123	\$4,709		\$1,796	\$17,649	\$9,007
YR-2008		\$4,205	\$6,368	\$4,535		\$1,868	\$18,355	\$8,673
YR-2009		\$4,374	\$6,623	\$4,367		\$1,943	\$19,089	\$8,352
YR-2010	\$14,551	\$4,549	\$6,888	\$9,555	\$86,042	\$3,032	\$29,779	\$43,702
YR-2011		\$4,730	\$7,163	\$4,049		\$3,154	\$30,970	\$11,618
YR-2012		\$4,920	\$7,450	\$3,899		\$3,280	\$32,209	\$11,188
YR-2013		\$5,116	\$7,748	\$3,755		\$3,411	\$33,498	\$10,773
YR-2014		\$5,321	\$8,058	\$3,616		\$3,547	\$34,837	\$10,374
YR-2015		\$5,534	\$8,380	\$3,482		\$3,689	\$36,231	\$9,990
YR-2016		\$5,755	\$8,715	\$3,353		\$3,837	\$37,680	\$9,620
YR-2017		\$5,986	\$9,064	\$3,229		\$3,990	\$39,187	\$9,264
YR-2018		\$6,225	\$9,426	\$3,109		\$4,150	\$40,755	\$8,921
YR-2019		\$6,474	\$9,803	\$2,994		\$4,316	\$42,385	\$8,590
YR-2020		\$6,733	\$10,195	\$2,883		\$4,489	\$44,080	\$8,272
YR-2021		\$7,002	\$10,603	\$2,776		\$4,668	\$45,844	\$7,966
YR-2022		\$7,282	\$11,027	\$2,674		\$4,855	\$47,677	\$7,671
YR-2023		\$7,574	\$11,468	\$2,575		\$5,049	\$49,585	\$7,387
YR-2024		\$7,877	\$11,927	\$2,479		\$5,251	\$51,568	\$7,113
YR-2025		\$8,192	\$12,404	\$2,387		\$5,461	\$53,631	\$6,850

Table 7: Emergency Power System Life Cycle Cost Comparison

**PAE Consulting Engineers**

Project: WSU - Vancouver Campus  
 Job No.: 6851  
 Calc By: JPG

Page: 1 of 1  
 Date: 9/4/92

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST
<b>CENTRAL PLANT GENERATION OPTION - PH I</b>				
500kw Generator	1	ea	75000.00	75000
Distribution Board	1	ea	20000.00	20000
Automatic Transfer Switch - 60A	4	ea	2000.00	8000
System Control and Remote Annunciation	1	ls	20000.00	20000
4-250 MCM Bldg 1,4 feeder	1300	lf	8.00	10400
4-#3 Bldgs 2,3 feeder	1400	lf	4.00	5600
4-#4 Bldg 5 Feeder	75	lf	3.00	225
6-Cell Duct	1500	ft	37.00	55500
Pull Box, 4'x4'x4'	4	ea	1475.00	5900
4" PVC Underground Raceway To Bldg	1000	lf	15.00	15000
Central Plant Space Development	750	sf	40.00	30000
Sub Total				<u>\$245,625</u>
Projected to 1998				<u><u>\$310,794</u></u>
<b>PHASE II</b>				
Transfer Switch - 60A	2	ea	2000.00	4000
4-#3 Bldg Feeders	1000	lf	4.00	4000
4" PVC Underground Raceway To Bldg	500	lf	15.00	7500
Sub Total				<u>\$11,500</u>
Projected to 2010				<u><u>\$14,551</u></u>

**Table 8: Central Plant Generation Constuction Estimate**

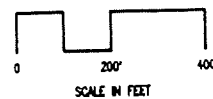
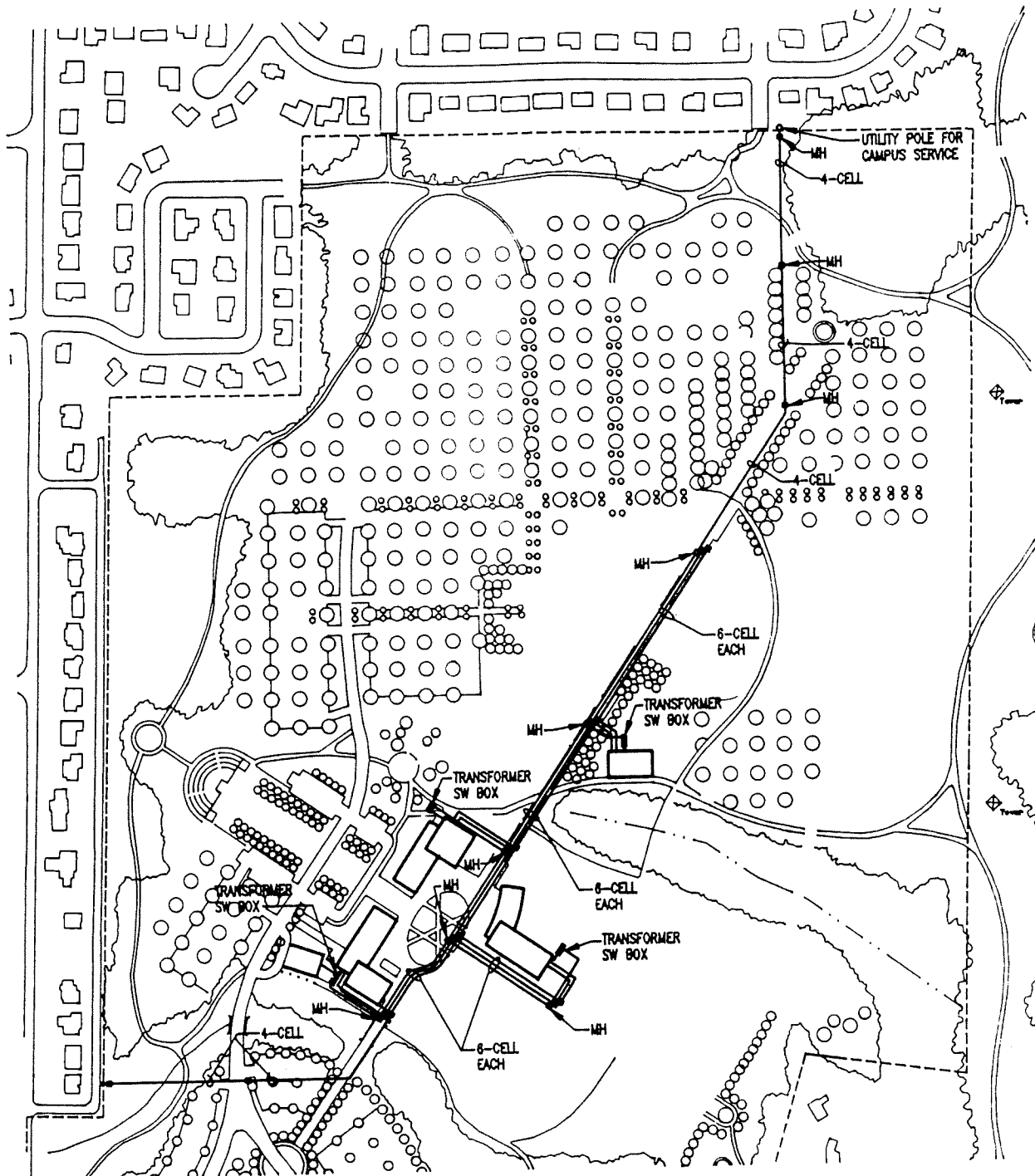
**PAE Consulting Engineers**

Project: WSU - Vancouver Campus  
 Job No.: 6851  
 Calc By: JPG

Page: 1 of 1  
 Date: 9/4/92

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST
<b>DE-CENTRAL GENERATION OPTION - PH I</b>				
50kw Generator	4	ea	20000.00	80000
Automatic Transfer Switch - 60A	4	ea	2000.00	8000
System Control and Remote Annunciation	1	ls	20000.00	20000
Gen Rm Space Development	600	sf	80.00	48000
Sub Total				<u>\$156,000</u>
Projected to 1998				<u><u>\$197,390</u></u>
<b>PHASE II</b>				
50 kw generator	2	ea	20000.00	40000
Transfer Switch - 60A	2	ea	2000.00	4000
Gen Rm Space Development	300	sf	80.00	24000
Sub Total				<u>\$68,000</u>
Projected to 2010				<u><u>\$86,042</u></u>

**TABLE 9: Individual Building Generation Construction Estimate**

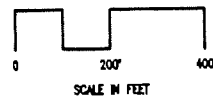
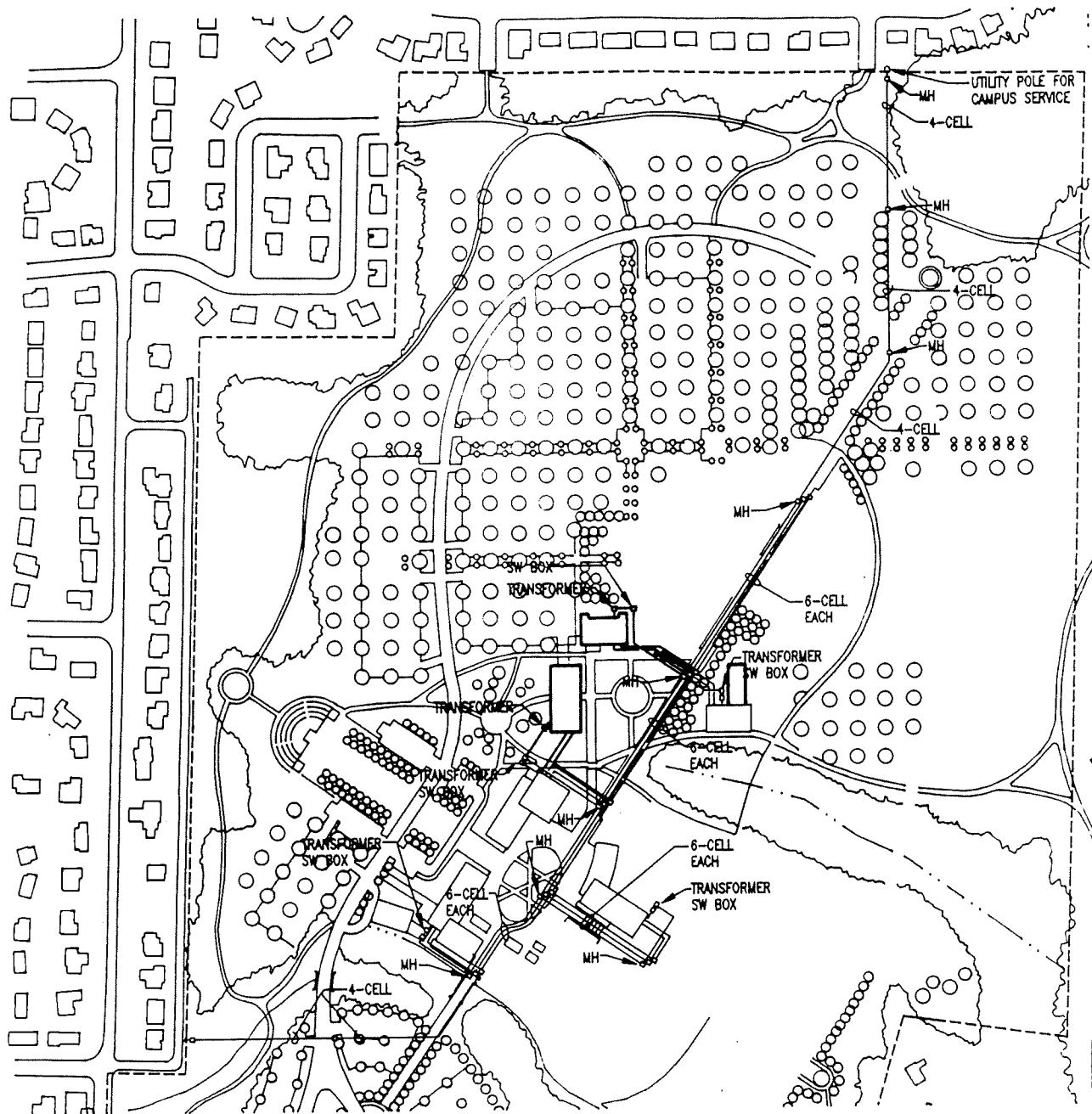


## **PHASE I DEVELOPMENT ELECTRICAL MASTER PLAN**



PAE Consulting Engineers Inc.

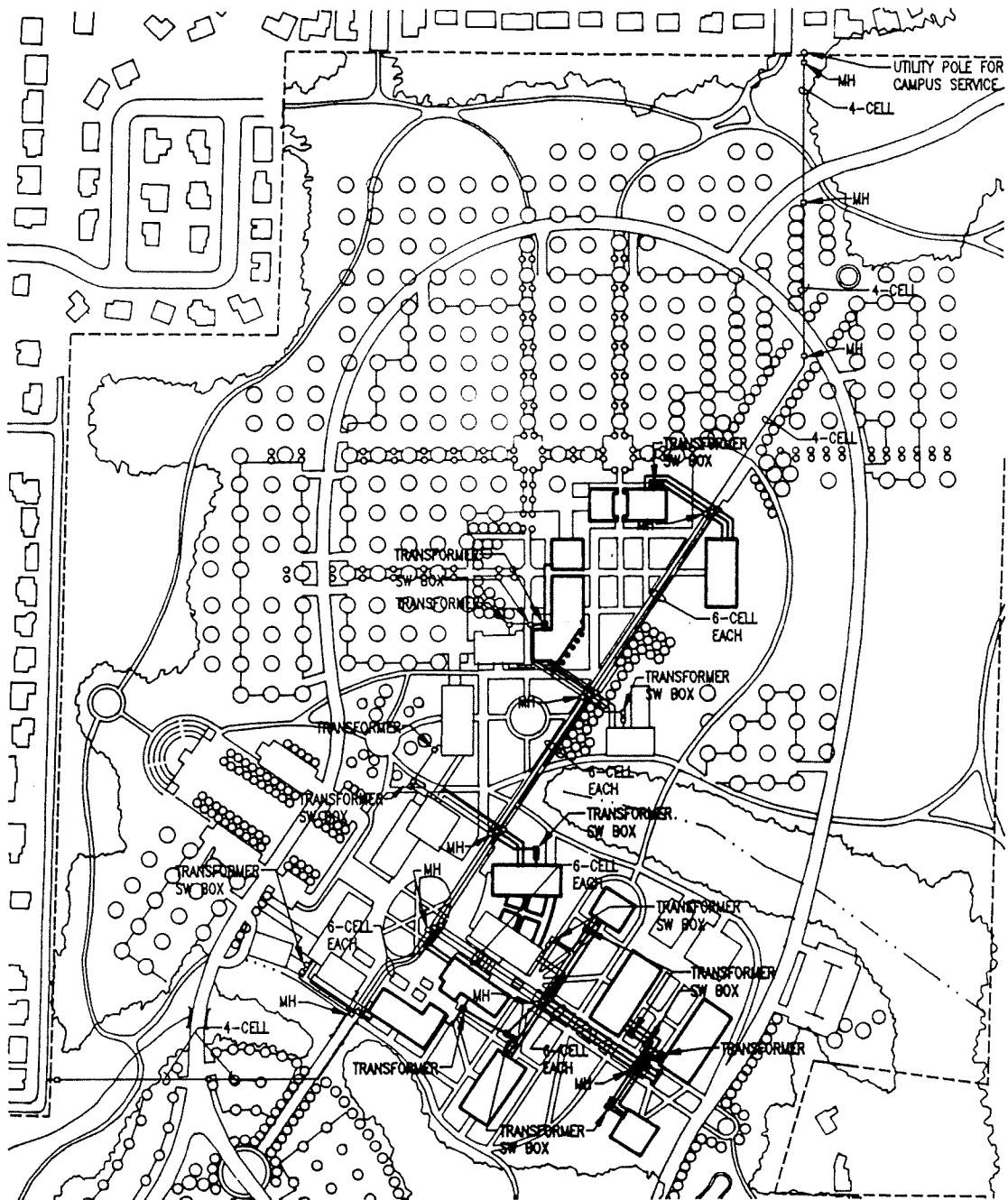
808 S.W. 3rd Avenue  
Portland, Oregon  
97204-2428  
503/226-2921



## PHASE II DEVELOPMENT ELECTRICAL MASTER PLAN

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97204-2428  
503/228-2921



## PHASE III DEVELOPMENT ELECTRICAL MASTER PLAN



PAE Consulting Engineers Inc.

808 S.W. 3rd Avenue  
Portland, Oregon  
97204-2428  
503/228-2921

WSU VANCOUVER  
MECHANICAL REPORT  
September 15, 1992

I SCOPE

- A. To determine the mechanical system approach which will satisfy requirements of heating and cooling the planned campus facilities in the most cost effective and energy efficient method possible.
- B. Provide a system approach which is inherently flexible and can allow future changes in utility rates and structure, economic conditions, advances in equipment designs, and program changes to be accomplished in a cost effective approach while serving current and future campus requirements.

II RECOMMENDATIONS

- A. Heating: Recommended approach is to install high efficiency condensing type gas fired hot water boilers in each building. Each building provided with air handling units of system type applicable to that facility with hot water heating coils. Gas metered centrally at the central plant. Standby boilers to be provided.
- B. Cooling: Recommended approach is to install water cooled centrifugal chillers at the central plant providing chilled water to buildings via direct buried pre-insulated piping. Variable speed chilled water pumps used to provide chilled water as required. Air handlers in each building provided with chilled water cooling coils with two way valve control to vary primary chilled water dependent upon cooling load. Cooling towers provided at central plant for heat rejection. Standby provisions at central plant to be provided. System designed to allow future expansion of chilled water plant as additional buildings are built, to allow chilled water storage systems to be incorporated into the system if economically justifiable, to allow parallel/series chiller arrangement if justifiable, and to allow gas fired absorption alternative if utility rates change to justify.
- C. Building Systems: Each building provided with system selected to provided required performance at most effective cost. Systems recommended generally are all air handling type central fan units with heating and cooling coils.

Dual duct variable air volume air distribution systems are the recommended approach which minimizes energy consumption while generally locating most equipment requiring maintenance in mechanical spaces and reduces maintenance in occupied spaces. Interior spaces may be single duct variable air volume units. Single duct variable air volume terminals with hot water reheat coils is recommended if dual duct variable air volume is not feasible. Fan powered terminals are not recommended due to higher maintenance requirements in occupied spaces.

- D. Controls: Recommended approach is to provide a direct digital control system monitoring and controlling all individual building systems and interfacing with a central computer to optimize central plant and building operations. Maintenance schedules, equipment monitoring and alarms, start/stop, optimization, energy consumption, lighting control, etc. should be incorporated. Terminal units should incorporate DDC control. Pneumatic controls used only for valve and damper operation where electric operation is not economical. System architecture should be such as to be universally addressable by several manufacturers of DDC controls.
- E. Energy Smart Design: Design assistance is available from the local utility for energy efficiency recommendations. The list of ECM's will be done normally at the design development stage in the design process. The service is free and provides cost incentives, depending upon the ECM's. This process should be a part of the design phase.

### III APPROACHES

- A. In analyzing various system approaches, the extent of the current master plan development of the building did not allow precise calculations of loads or equipment usages. Therefore, calculations have been made based upon various assumptions as stated in the calculation portion and our past experience for this facility type. The loads are sufficient for comparative purposes, but should not be taken as actual loads. It was assumed that cooling could be accomplished with outside air during favorable temperature conditions, thus reducing the operations of chillers. Energy calculations should at this time not be assumed as an indication of actual energy usages.
- B. Cost estimates were made using actual costs received from vendors and cost estimating guides such as the latest edition of Means and our own experience in construction costs.



- C. Life cycle cost analysis was made using initial first cost items, maintenance, energy cost with inflation, interest and future additional capital and replacement costs amortised to current costs, and summarized. Summary costs were used to compare system results.
- D. In system comparisons, advantages and disadvantages have been provided for performance evaluations. Systems have been costed to provide comparable performances, that is, if the central plant approach provides standby, than the decentral plant approach was costed with comparable standby provisions. Heat pump system comparisons were provided with two machines each sized per 50% of total required.
- E. A comparison was made providing all utilities in a single tunnel verses the separate direct bury installation for electrical utilities and chilled water supply and return piping. Results are included hereafter.
- F. Thermal storage systems are not currently included in the master plan analysis. Storage in the form of chilled water or ice is an option currently to reduce the size of the initial central plant chilled water equipment and provide off-peak sources of chilled water if necessary. Since the analysis indicates that central plant is the preferred approach, analysis of storage is an economic consideration based upon accurate loads, an understanding of equipment operation requirements and cost analysis. The depth of this study does not allow this sophistication of study, and is a recommendation to be considered in the next phase.
- G. It was assumed that cooling would be accomplished with outside air during favorable temperature conditions using outside air economizer cycles, thus reducing the need to operate the chillers. Heat pump operation was based upon the need to operate continuously to provide either heating or cooling with minimum outside air as required for code ventilation and adequate indoor air quality control.

#### IV DESIGN PARAMETERS AND LOADS

##### A. Parameters:

- 1. General: The design parameters used were in accordance with the State of Washington Energy Codes and as follows:
  - a. R-11 walls with 20% double glass.
  - b. R-19 roof.
  - c. 15 cfm OSA/person.

- d. 0.5 Mbh/person heat gain.
- e. Heating from 23°F to 70°F.
- f. Cooling from 86/67°F to 78°F.
- g. 15 mph wind.

2. Heating Factors:

- a. Wall  $0.25 \times 55^\circ = 13.75$  Btu/SF.
- b. Roof  $0.035 \times 55 = 2.0$  Btu/SF.
- c. Floor perimeter  $0.65 \times 55 = 36$  Btu/Ft.

3. Cooling Factors: building peak from 3 to 4 PM.

a. Exposures:

<u>Direction</u>	<u>Glass</u>	<u>Wall</u>	<u>20/80 Comp.</u>	<u>Use</u>
NE	40	4	11.2	12 btu/SF
NW	40	4	11.2	12 btu/SF
SE	40	6	12.8	13 btu/SF
SW	100	4	23.2	25 btu/SF

b. Internal Electrical Loads:

<u>Area</u>	<u>Watts/SF</u>	<u>Btu/SF</u>
Offices	4	13.7
Library	3	10.2
Classrooms	2.5	8.5
Research Labs	8	27.3
Computer Labs	6	20.5
Lecture Halls	4	13.7
Child Care	2	6.8
Kitchen	15	51.2
Dining	4	13.7

B. Heating and Cooling Loads: Building totals are as follows. For Calculations, see Appendix A.

Building	Phase I		Phase II		Phase III	
	Heating Mbh	Cooling Mbh	Heating Mbh	Cooling Mbh	Heating Mbh	Cooling Mbh
Bldg. 1	2,321	1,463	2,426	1,529	2,426	1,529
Bldg. 2	1,911	1,595	2,318	1,935	2,318	1,935
Bldg. 3	2,849	2,007	2,849	2,007	2,849	2,007
Bldg. 4	321	266	378	322	378	322
Bldg. 5/6	645	461	2,067	1,477	2,067	1,477
Bldg. 7/8	-	-	4,200	2,959	4,200	2,959
Phase III	-	-	-	-	14,238	10,229
Total	8,038	5,792	14,239	10,229	28,478	20,458

## V HEATING

### A. Energy Source

1. Systems considered for possible energy source were gas, electricity, oil, heat pumps, solar, geotherm and co-generation. Sources considered as not meeting the scope requirements were eliminated from further study for reasons as follows:
  - a. Electric heating was eliminated because of its initial and annual long term higher operating costs.
  - b. Oil was eliminated because of its higher operating costs, higher maintenance costs and higher pollution rates. Long term source was also a concern.
  - c. Ground water source heat pumps were eliminated because there is no history of ground water in the amounts required being available in the area and costly test wells would be required prior to design.
  - d. Air to air heat pumps were eliminated because of their visual and noise impact at all the buildings, lower efficiencies, high maintenance cost and intensity of maintenance in occupied areas of the buildings.
  - e. Solar was eliminated because of its high installation cost, negative visual impact, unreliability and need for a backup heating system.
  - f. Geotherm was eliminated as there is no known evidence of a possible source on the site.

- g. Cogeneration was eliminated because it is not economical feasible with current gas and electric rates. Cogeneration could become feasible depending upon future rate changes.
2. Gas and hydronic heat pumps were considered to be the most feasible for further in-depth study as the energy source.

#### B. Gas Metering

1. Gas can be metered either by a campus meter or by individual building meters.
2. Campus Gas Meter: A single gas meter would distribute 5 psi gas to all the buildings.

##### Advantages:

- Able to utilize schedule 4, large firm service. See applicable gas rates in Appendix B.
- If economically feasible in the future, easy to add gas storage or standby fuel to utilize Schedule 23, interruptable service. Initial estimate was \$100,000 to add 10,000 gallons of propane storage with an air-propane mixer suitable for standby. This cost cannot be justified initially, but may be viable as utility rates and operating factors change in the future.

##### Disadvantages:

- University responsible for installation and maintenance of the distribution system from the meter to the buildings.
3. Individual Building Gas Meters: A meter installed at each building.

##### Advantages:

- Gas company will maintain the gas distribution systems.
- Can monitor individual building gas consumption.

##### Disadvantages:

- Schedule 3 is the only feasible gas rate for the individual meter.

- Future addition of standby fuel or storage is not feasible.

4. 1998 Annual Costs:

a. Decentral Plants Heating	
Individual Meters (Sched. 3)	\$49,651
Common Meter (Schedule 4)	<u>\$46,635</u>

1998 Annual Saving Using Common Meter      \$ 3,136

- b. See appendix B for rate schedules and calculations.

C. Heating Water Distribution:

1. Three methods, walk through tunnel, precast trench and direct bury, were analyzed for distribution of the heating water from the central plant to the buildings.
2. All three were based on 5,792 Mbh for Phase I, 10,229 Mbh total for Phase II and 20,458 Mbh total for Phase III. See Summary of Campus Heating and Cooling Loads in Appendix A for calculations.
3. At approximately 40°F temperature drop the pumped gallons is a total of 300 gpm for Phase I, 500 gpm for Phase II and 1000 gpm for Phase III.
4. The mains were sized for the total of Phase III.
5. Walk Through Tunnels: Poured in place walk through tunnel constructed and sized in accordance with WSU standards. Tunnel extended as required to accommodate Phases II and III with minimum disruption to Phase I campus when Phases II and III are constructed. Piping sized for phases I, II and III but installed only for Phase I.

Advantages:

- Easy to inspect, maintain and modify the piping.

Disadvantages:

- Cost.

6. Precast Trench: 5'-0"x4'-0" pre-cast trench similar to Utility Vault 4860 for main run with manholes and direct bury branches to buildings. Trench extended as required to accommodate Phases II and III with minimum disruption of Phase I campus when Phases II and III are constructed. Piping sized for phases I, II and III but installed only for Phase I.

Advantages:

- Less expensive than tunnel with almost as much flexibility of the tunnel.
- Ease of construction.

Disadvantages:

- For proper access top must be at grade making it more difficult to fit into the campus landscape and contours.
- Size not adequate for all services and still accommodate maintenance personnel access.

7. Direct Bury Piping: Pre-insulated piping similar to Rovanco Insul-8 with steel carrier pipe. With anchors, expansion means and manholes at branch connections. Piping sized for Phases I, II and III and extended as required to accommodate Phases II and III with minimum disruption of Phase I campus when Phases II and III are constructed.

Advantages:

- Least costly.
- Easy to install.
- Non-scheduled connections easily made.

Disadvantages:

- More difficult to inspect/check piping.

8. Life Cycle Cost Analysis:

- a. The estimated 1998 first cost and maintenance cost for Phase I of the three systems are calculated in Appendix C with totals as follows:

		<u>First</u>	<u>Maintenance</u>
1)	Tunnel	\$1,335,491	\$5,700
2)	Prefab Trench	\$ 823,760	\$5,800
3)	Direct Bury	\$ 622,800	\$6,000

b. The estimated life cycle cost through year 2025 of the three systems plus the central plant are calculated in Heating Distribution System Life Cycle Cost Analysis in Appendix C with totals as follows:

1)	Tunnel	\$2,900,491
2)	Prefab Trench	\$2,269,900
3)	Direct Bury	\$2,138,244

D. Heating Plants:

1. A central campus heating plant with a direct buried distribution system and individual (decentralized) heating plants in each building were considered for the source of heating for the buildings on the campus.
2. See Appendix A for building loads.
3. Central plant with direct buried Distribution Piping: The Central Plant System would provide heating for the entire campus and would consist of multiple gas fired, heating water, fire tube boilers with variable volume pumps pumping the heating water to the buildings through a direct buried distribution system.
  - a. Boilers: Phase I would include three 2,856 Mbh boiler for the 5,792 Mbh load plus one standby boiler. Space would be provided for two additional boilers for Phase II and four additional boilers for Phase III.
  - b. Distribution System: Direct buried as discussed in C above.
  - c. Distribution Pumping System: Heating water will be pumped through the distribution system by two 250 gpm variable volume circulating pumps. A third pump will be provided for standby. Space would be provided for the addition of two pumps in Phase III.

Advantages:

- Less and centralized maintenance, reducing costs.
- One location for majority of equipment.
- Standby and backup provisions provided.

Disadvantages:

- Requires additional initial costs in Phase I for provisions for Phases II and III.
- Higher energy usage, 80% maximum efficiency with lower efficiency at part loads. The annual plant efficiency could easily be as low as 50-60%.
- Higher first cost and life cycle cost.
- Central Plant must operate to serve a single building.

4. Decentral Plants: Each building will have its own heating plant. The boilers will be gas fired, condensing type with a minimum efficiency of 93% regardless of load. A minimum of two boilers will be provided in each plant with 75% to 100% standby capacity.

Advantages:

- No provisions required for Phases II and III other than larger gas piping.
- Simpler system and less complicated controls.
- Greater flexibility for modification to campus layout.
- Lowest energy usage regardless of load.
- Does not require a campus distribution system.
- Lowest first and life cycle costs.

Disadvantages:

- Higher maintenance cost.
- Equipment not centralized.
- Requires boiler room in each building.



5. Life Cycle Cost Analysis:

- a. The 1998 first cost and Maintenance cost for Phase I of the two systems are estimated in Appendix C with totals as follows:

	<u>First</u>	<u>Maintenance</u>
1) Central Plant w/Direct Bury Distribution	\$ 622,800	6,000
2) Decentralized Plants	\$ 371,604	9,000

- b. The estimated life cycle costs through year 2025 of the systems are calculated in Appendix C with totals as follows:

1) Central Plant w/Direct Buried Distribution	\$2,138,244
2) Decentralized Plants	\$1,608,118

E. Recommendations:

1. Based upon above decentral plants are recommended because of lower costs, greater flexibility to changes, are less complicated to operate, and higher operating efficiency.
2. Based upon decentral heating plants, utilizing a common gas meter results in initial savings of approximately \$3,300. Additional savings will be achieved in Phases II and III.

VI COOLING

- A. Energy Source: Electricity and gas were considered as energy sources. Gas was eliminated because it is not currently economically feasible. A gas fired absorption alternative could be feasible in the future if utility rates change and equipment design improves.

B. Cooling Systems:

1. Systems considered were as follows. Systems considered as not meeting the scope requirements were eliminated from further study for reasons as follows:

- a. Air Cooled: Self-contained units, decentralized plant air cooled water chillers and decentralized plant water cooled chillers with individual cooling towers were eliminated because of objectionable visual and noise impact, lack of standby provisions, higher initial costs, higher operating cost and higher maintenance cost.
  - b. Decentralized plant water cooled chillers with central plant cooling towers were eliminated because decentral chillers have no standby provisions, higher initial costs, and higher operating and maintenance costs.
  - c. Ground water source decentralized or central plant chillers were eliminated because there is no history of ground water in the amounts required being available in the area.
  - d. Hydronic heat pump systems are considered a viable system and are compared with the central cooling plant under Section VII.
2. Central plant water chillers are considered the most feasible for further in-depth study.

C. Cooling Plant:

1. A central campus cooling plant with a campus chilled water distribution system was considered for the source of chilled water for cooling the buildings on the campus.
2. Central Plant: The central plant will provide chilled water for the entire campus. Two 250 ton high efficiency centrifugal chillers will be provided for phase I with a third 250 ton chiller for standby. Space will be provided for additional chillers and pumps for Phases II and III.

Advantages:

- Lower operating and maintenance cost.
- Higher system efficiency.
- Longer life expectancy.
- One location for majority of equipment.
- Ice storage, gas fired chillers or other energy saving features can be easily added if and when they become economically feasible.

Disadvantages:

- Requires additional cost in Phase I and provisions for Phase II and III.
- Requires distribution system.
- Central plant must operate to serve a single building.

D. Chilled Water Distribution:

1. Three methods, walk through tunnel, precast trench and direct bury, to distribute the chilled water from the central plant to the buildings were considered.
2. All three were based on 8,038 Mbh for Phase I, 14,239 Mbh total for Phase II and 28,478 Mbh total for Phase III. See Summary of campus heating and cooling loads in Appendix A for calculations.
3. At approximately 12°F temperature rise the pumped gallons of 1,400 gpm for Phase I, 2400 gpm for Phase II and 4800 gpm for Phase III.
4. The mains were sized for the total of Phase III.
5. Walk Through Tunnels: Poured in place walk through tunnel constructed and sized in accordance with WSU standards. Tunnel to house the chilled water piping. Tunnel extended as required to accommodate Phases II and III with minimum disruption to Phase I campus when Phases II and III are constructed. Piping sized for phases I, II and III but installed only for Phase I.

Advantages:

- Easy to inspect, maintain and modify the piping.

Disadvantages:

- Cost.
6. Precast Trench: 5'-0"x4'-0" pre-cast trench similar to Utility Vault 4860 for main run with manholes and direct bury branches to buildings. Trench extended as required to accommodate Phases II and III with minimum disruption of Phase I campus when Phases II and III are constructed. Piping sized for phases I, II and III but installed only for Phase I.

Advantages:

- Less expensive than tunnel with almost as much flexibility of the tunnel.

Disadvantages:

- For proper access top must be at grade making it more difficult to fit into the campus landscaping.
- Size not adequate.

7. Direct Bury Piping: Pre-insulated piping similar to Rovanco Insul-8 with non-metallic carrier pipe, with anchors, expansion means and manholes at branch connections. Piping sized for Phases I, II and III and extended as required to accommodate Phases II and III with minimum disruption of Phase I campus when Phases II and III are constructed.

Advantages:

- Least costly.

Disadvantages:

- More difficult to access piping.

8. Life Cycle Cost Analysis:

- a. The estimated 1998 first cost and maintenance cost for Phase I of the three systems are calculated in Appendix D with totals as follows:

	<u>First</u>	<u>Maintenance</u>
1) Tunnel	\$1,310,260	\$2,700
2) Prefab Trench	\$ 794,292	\$2,800
3) Direct Bury	\$ 709,844	\$3,000

- b. The estimated life cycle cost, through year 2025, of the three systems are calculated in Appendix D with totals as follows:

1) Tunnel	\$1,401,075
2) Prefab Trench	\$ 852,716
3) Direct Bury	\$ 771,530

E. Recommendations:

1. Central plant chillers and a direct bury distribution system is recommended as the most flexible, least costly, and most energy efficient system.
2. Decentral plants are not recommended due to noise of visual impacts, greater installed tonnage, higher costs, and higher energy and maintenance costs.

VII HEAT PUMP

- A. A hydronic heat pump with direct buried distribution system was considered in lieu of the recommended central cooling with direct buried distribution and decentralized heating.

Discussion was held with the Washington State Department of Energy Office. We understand no current program exists for partial funding or studies for hydronic heat pump systems. Discussions with a school district in Puyallup were generally favorable in their success with a hydronic heat pump system using smaller individual replaceable units. However, these were individual building systems only and they have not been operating long enough to experience replacement maintenance.

B. Description:

1. A condenser/evaporator water direct buried distribution system will circulate water from the central plant to the heat pumps in each building.
2. When the campus requires heating, heat will be supplied to the distribution system by six (6) gas fired, condensing type boilers with a minimum efficiency of 93%. A seventh boiler will be installed for standby.
3. When the campus requires cooling, heat will be dissipated from the distribution system by cooling towers with one standby tower. Heat will be transferred from the distribution system to the towers through a water-to-water heat exchangers to preclude contaminating the distribution system water.
4. Each building will be served by two reciprocating heat pumps with double bundle evaporator and double bundle condenser. The second bundle in the evaporator will add heat from the distribution system and the second bundle in the condenser will dissipate heat to the distribution system. Each heat pump will be sized for 50 percent of the building load for partial standby.

- C. Comparison: In comparison with a decentral heating system and central cooling system with direct buried chilled water piping, the heat pump systems have advantages and disadvantages as follows:

Advantages:

- Lower operation cost.

Disadvantages:

- Higher first cost.
- Higher maintenance cost.
- Higher life cycle costs.
- More complex control system.
- Limited possibilities for future addition of energy efficient features.

D. Life Cycle Costs:

1. The estimated 1998 first cost and maintenance cost for Phase I of the two systems are calculated in Appendix E with totals as follows:

	<u>First</u>	<u>Maintenance</u>
a. Heat Pump	\$2,709,110	\$15,000
b. Central Cooling/ Decentral Plant Heating	\$1,660,396	\$13,500

2. The estimate life cycle cost through year 2025 of the two systems are calculated in Appendix E with totals as follows:

a. Heat Pump	\$5,126,163
b. Central Cooling/ Decentral Plant Heating	\$4,199,134

- E. Recommended Approach: The Central Cooling/Decentral heating is recommended because of the lower first cost, lower life cycle cost and the possibility for modification to include future energy efficient features.

## VIII COMBINED TUNNEL APPROACH

- A. A walk through tunnel housing the chilled water piping, primary electrical service, communications and emergency power was considered in lieu of the recommended central cooling with direct buried distribution piping and electrical ductbanks.
- B. Description: Poured in place walk through tunnel constructed and sized in accordance with WSU standards. Tunnel extended as required to accommodate Phases II and III with minimum disruption to Phase I campus when Phases II and III are constructed. Services sized for Phases I, II and III but installed only for Phase I.

### Advantages:

- Easy to inspect, maintain and modify the services.

### Disadvantages:

- Cost.

### C. Life Cycle Costs:

1. The estimated 1998 first cost and maintenance cost for Phase I of the two systems are calculated in Appendix F with totals as follows:

	<u>First</u>	<u>Maintenance</u>
a. Combined Tunnels	\$1,194,852	\$ 2,700
b. Direct Bury	\$ 709,844	\$ 3,000

2. The estimated life cycle cost through year 2025 of the two systems are calculated in Appendix F with totals as follows:

a. Combined Tunnel	\$1,280,991
b. Direct Bury	\$ 771,530

- D. Recommendation: The direct buried distribution piping and separate ductbanks are recommended with the lower first cost and lower life cycle cost.

IX UTILITY REQUIREMENTS:

Estimate utility requirements through 2025.

<u>ITEM</u>	<u>PHASE I</u> <u>1998</u>	<u>PHASE II</u> <u>2010</u>	<u>PHASE III</u> <u>2025</u>	<u>TOTAL</u>
Building Area (SF)	241,500	143,961	385,461	770,922
CW (GPM)	180	240	400	400
San Sewer (FU)	1,000	600	1,600	3,200
Gas (MBH)	11,500	5,200	15,000	31,700
Heating (MBH)	5,800	4,400	10,000	20,200
Cooling (Tons)	670	500	1,200	2,370

6851/Reports/pkh  
9-15-92



**APPENDIX A**  
**BUILDING LOAD CALCULATIONS**

**PAE Consulting Engineers Inc.**

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 1  
 Date: 9/4/92  
 File: HTG & CLG LOADS

**SUMMARY OF CAMPUS HEATING AND COOLING LOADS**

BUILDING	SF	COOLING				HEATING		
		VENT MBH	PEOPLE MBH	BLDG MBH	TOTAL MBH	VENT MBH	BLDG MBH	TOTAL MBH
PHASE I								
BLDG - 1	74,612	298	601	1,422	2,321	1,091	372	1,463
BLDG - 2	63,080	343	694	874	1,911	1,258	337	1,595
BLDG - 3	70,630	425	858	1,566	2,849	1,557	450	2,007
BLDG - 4	9,690	46	93	173	312	168	98	266
BLDG - 5/6	21,590	(EST.)			645			461
TOTALS	241,500				8,038			5,792
PHASE II								
BLDG - 1	77,330				2,426			1,529
BLDG - 2	75,080				2,318			1,935
BLDG - 3	70,630				2,849			2,007
BLDG - 4	10,200				378			322
BLDG - 5/6	59,064	(EST.)			2,067			1,477
BLDG - 7/8	86,250	(EST.)			4,200			2,959
TOTALS	385,461				14,238			10,229
PHASE III								
I & II	385,461				14,238			10,229
III	385,461	(EST.)			14,238			10,229
TOTAL	770,922				28,476			20,458

PAE Consulting Engineers Inc.

Project: WSU VANCOUVER CAMPUS  
Job No.: 6851.00  
Calc By: NPC

Sheet No.: 2  
Date: 9/4/92  
File: HTG & CLG LOADS

Assumptions:

1. Double Glass
2. R-11 Walls
3. R-19 Roof
4. 20% Glass
5. Heating from 23°F to 70°F
6. Cooling from 86/67°F to 78°F
7. 15 cfm OSA/person
8. 0.5 MBH/person heat gain

Heating

Wall  $0.25 \times 47 = 11.75$  Btu/SF  
Roof  $0.035 \times 47 = 1.65$  Btu/SF  
FLR perimeter  $0.65 \times 47 = 30.55$  Btu/LF

Cooling

Building peak from 3:00 to 4:00 PM - South West

DIRECTION	GLASS	WALL	20/80 COMP.USE	(BTUH/SF)
NE	40	4	11.2	12
NW	40	4	11.2	12
SE	40	6	12.8	13
SW	100	4	23.2	25

Electric Load per SF

AREA	WATTS/SF	BTU/SF
OFFICES	4	13.7
LIBRARY	3	10.2
CLASSROOMS	2.5	8.5
RESEARCH LAB	8	27.3
COMPUTER LABS	6	20.5
LECTURE HALL	4	13.7
CHILD CARE	2	6.8
KITCHEN	15	51.2
DINING	4	13.7

**PAE Consulting Engineers Inc.**

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 3  
 Date: 9/4/92  
 File: HTG & CLG LOADS

**BUILDING VENTILATION LOAD**

BUILDING & ITEM	AREA SF	SF/PERSON	PEOPLE	VENT CFM	VENT LOADS MBH	
					COOLING	HEATING
<b>BLDG - 1 TOTALS</b>			<b>1,202</b>	<b>18,032</b>	<b>298</b>	<b>1,091</b>
DINING	13,500	15	900			
KITCHEN	7,955	200	40			
OFFICES	19,300	100	193			
CORR & MISC	20,800	300	69			
<b>BLDG - 2 TOTALS</b>			<b>1,387</b>	<b>20,800</b>	<b>343</b>	<b>1,258</b>
LIBRARY	31,000	50	620			
CLASSROOMS	11,000	15	733			
CORR & MISC	10,000	300	33			
<b>BLDG - 3 TOTALS</b>			<b>1,716</b>	<b>25,736</b>	<b>425</b>	<b>1,557</b>
COMPUTER LABS	6,580	50	132			
RESEARCH LABS	24,510	50	490			
WHET & OPEN LABS	8,670	50	173			
LECTURE HALL	6,150	7	879			
CORR & MISC	12,590	300	42			
<b>BLDG - 4 TOTALS</b>			<b>186</b>	<b>2,785</b>	<b>46</b>	<b>168</b>
CHILD CARE	6,300	35	180			
CORR & MISC	1,700	300	6			

Project: WSU VANCOUVER CAMPUS  
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File: HTG & CLG LOADS

## BUILDING AREAS

## BUILDING - 1

GROSS AREA = 74,612  
4 FLOORS = 18,653 SF/FLR = 186' x 100'  
NW & SE WALLS = 186' x 40' = 7440 SF  
NE & SW WALLS = 100' x 40' = 4000 SF  
ROOF = 18,653 SF  
FLOOR EDGE = 2(186 + 100) = 570

## BUILDING - 2

GROSS AREA = 63,080  
4 FLOORS = 16,000 SF/FLR = 160' x 100'  
NW & SE WALLS = 160' x 40' = 6400 SF  
NE & SW WALLS = 100' x 40' = 4000 SF  
ROOF = 16,000 SF  
FLOOR EDGE = 2(160 + 100) = 520

## BUILDING - 3

GROSS AREA = 70,630  
4 FLOORS = 17,660 SF/FLR = 160' x 110'  
NW & SE WALLS = 160' x 40' = 64000 SF  
NE & SW WALLS = 110' x 40' = 4400 SF  
ROOF = 17,660 SF  
FLOOR EDGE = 2(160 + 110) = 540

## BUILDING - 4

GROSS AREA = 9,690  
2 FLOORS = 4,920 SF/FLR = 82' x 60'  
NW & SE WALLS = 60' x 20' = 1,200 SF  
NE & SW WALLS = 82' x 20' = 1,640 SF  
ROOF = 4,9200 SF  
FLOOR EDGE = 2(82 + 60) = 284

PAE Consulting Engineers Inc.

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

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 File: HTG & CLG LOADS

BUILDING LOADS

BUILDING LOADS	AREA	HEATING MBH	COOLING MBH
<b>BUILDING - 1</b>		<b>372</b>	<b>1422</b>
NW WALL	7,440	102	89
NE WALL	4,000	55	48
SE WALL	7,440	102	97
SW WALL	4,000	55	100
ROOF	18,650	37	112
FLOOR	570	21	0
INTERNAL HTG GAINS			
DINING	13,500		184
KITCHEN	7,955		406
OFFICES	19,300		262
CORR & MISC	20,800		125
<b>BUILDING - 2</b>		<b>337</b>	<b>874</b>
NW WALL	6,400	88	77
NE WALL	4,000	55	48
SE WALL	6,400	88	83
SW WALL	4,000	55	100
ROOF	16,000	32	96
FLOOR	520	19	0
INTERNAL HTG GAINS			
LIBRARY	31,000		316
CLASSROOMS	11,000		94
CORR & MISC	10,000		60

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 6  
 Date: 9/4/92  
 File: HTG & CLG LOADS

## BUILDING LOADS

BUILDING LOADS	AREA	HEATING MBH	COOLING MBH
<b>BUILDING - 3</b>		<b>352</b>	<b>1566</b>
NW WALL	6,400	88	77
NE WALL	4,400	61	53
SE WALL	6,400	88	83
SW WALL	4,400	61	110
ROOF	17,660	35	106
FLOOR	540	19	0
INTERNAL HTG GAINS			
COMPUTER LABS	6,580		134
RESEARCH LABS	24,510		667
WHET & OPEN LABS	8,670		177
LECTURE HALL	6,150		84
CORR & MISC	12,590		76
<b>BUILDING - 4</b>		<b>0</b>	<b>93</b>
NW WALL	1,200	17	14
NE WALL	1,640	23	20
SE WALL	1,200	17	16
SW WALL	1,640	23	41
ROOF	4,920	10	30
FLOOR	284	10	0
INTERNAL HTG GAINS			
CHILD CARE	6,300		43
CORR & MISC	1,700		10

**APPENDIX B**  
**GAS METERING COMPARISON**



Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 1  
 Date: 9/4/92  
 FILE: BIN ENERGY EST.

CAMPUS ANNUAL GAS USAGE FOR HEATING

BUILDING	SUMMARY CHART			
	PHASE I THERMS		PHASE II THERMS	
	CENTRAL	DECENTRAL	CENTRAL	DECENTRAL
1	23,126	19,474	1,050	884
2	32,094	27,027		
3	28,968	24,394		
4	4,880	4,110		
5/6 (EST)	9,124	7,683	20,123	16,946
7/8 (EST)			42,709	35,965
TOTAL	98,192	82,688	63,883	53,796
COST (1)	51,173	37,586	33,293	24,453
FV 1998	63,493	46,635	41,308	30,340

NORTHWEST NATURAL GAS COMPANY  
RATE SUMMARY OF GAS SCHEDULES: EFFECTIVE DECEMBER 1, 1991

TARIFF WN U-5  
WASHINGTON

<p><b>SCHEDULE 1</b> GENERAL SERVICE</p> <p>Monthly Rate \$ 3.02 1st 2 Therms 64.548¢ Next 48 Therms 61.634¢ All Add'l Therms Minimum Monthly Bill: \$ 3.02</p>	<p><b>SCHEDULE 2</b> RESIDENTIAL SERVICE</p> <p>Monthly Rate \$ 5.40 1st 6 Therms 51.782¢ Next 34 Therms 46.786¢ All Additional therms Minimum Monthly Bill \$ 5.40</p>	<p><b>SCHEDULE 3</b> COM'L AND INDUSTRIAL SERVICE</p> <p>Monthly Rate \$ 7.14 1st 10 Therms 54.835¢ Next 290 Therms 48.312¢ Next 1,700 Therms 44.705¢ All Additional Therms Minimum Monthly Bill \$ 7.14</p>	<p><b>SCHEDULE 4</b> LARGE FIRM SERVICE</p> <p>Monthly Rate 43.040¢ 1st 4,000 Therms 39.015¢ Next 6,000 Therms 37.905¢ All Additional Therms Minimum Monthly Bill \$ 797.01</p>	<p><b>SCHEDULE 5</b> ILL.F. LARGE FIRM SERVICE</p> <p>Monthly Rate 35.407¢ per therm Minimum: Monthly - 90% of Max. Day Del. Vol. Annual - 95% of Max. Day Del. Vol.</p>
<p><b>SCHEDULE 11</b> SEASONAL SWING AND OFF-PEAK FIRM SERVICE (Optional)</p> <p>Monthly Rate Apr-Oct 43.595¢ 1st 200 Therms 35.962¢ Next 4,800 Therms 35.269¢ All Additional Therms Mar &amp; Nov 45.259¢ 1st 1,000 Therms 38.044¢ Next 1,000 Therms 37.766¢ All Additional Therms Dec, Jan, Feb 81.755¢ 1st 800 Therms 57.887¢ Next 1,200 Therms 51.088¢ All Additional Therms Minimum Monthly Bill \$78.62 Per Month for Billing Cycles July, August, September</p>	<p><b>SCHEDULE 12</b> GAS LIGHT SERVICE</p> <p>Monthly Rate One Mantle \$ 7.49 All Additional Mantles \$ 6.79 FROZEN SCHEDULE 16 GAS EQUIPMENT RENTAL SERVICE Monthly Rental Charge \$2.87 per month AWH Automatic Water Heater \$4.10 per month Gas Space Heating Equipment Heating Equipment \$6.17 per month AWH and Gas Space Heating Equipment FROZEN</p>	<p><b>SCHEDULE 21</b> FIRM SERVICE HIGH LOAD FACTOR (Optional)</p> <p>Monthly Rate 1st 500 Therms \$232.81 Next 1,500 Therms 39.432¢ Next 98,000 Therms 36.795¢ All Additional Therms 35.962¢ Minimum Monthly Bill \$ 232.81 Peak Surcharge 10.4¢</p>	<p><b>SCHEDULE 22</b> DUAL FUEL SERVICE</p> <p>Monthly Rate 1st 1,000 Therms \$ 406.58 Next 9,000 Therms 37.350¢ Next 10,000 Therms 35.347¢ All Additional Therms 34.713¢ Minimum Monthly Bill \$ 406.58 FROZEN</p>	<p><b>SCHEDULE 23</b> INTERRUPTIBLE SERVICE (Optional)</p> <p>Monthly Rate 1st 7,000 Therms \$ 2,313.15 Next 7,000 Therms 31.426¢ Next 86,000 Therms 30.592¢ Next 1,500,000 Therms 30.038¢ All Additional Therms 29.344¢ Minimum Monthly Bills 2,313.15</p>
<p><b>SCHEDULE 10</b> SUPPLEMENTARY METER RENTAL</p> <p>Monthly Rental Charges 1st 150 CF per Hr. per Mo. Cap 38.6¢ Next 650 CF per Hr. per Mo. Cap 15.7¢ All Add'l CF per Hr. per Mo. Cap 22.9¢ Min. Monthly Rental \$0.38 Charge for Meter Reading \$0.34</p>	<p><b>SCHEDULE 24</b> RESIDENTIAL SERVICE ALL GAS</p> <p>Monthly Rate 1st 16 Therms \$ 8.90 Next 184 Therms 47.312¢ All Additional Therms 43.178¢ Minimum Monthly Bill \$ 8.90</p>	<p><b>SCHEDULE 26</b> RESIDENTIAL SERVICE AIR CONDITIONING</p> <p>Monthly Rate 1st 16 Therms \$ 8.83 Next 44 Therms 46.509¢ All Additional Therms 42.485¢ Minimum Monthly Bill \$ 8.83</p>	<p><b>SCHEDULE 27</b> RESIDENTIAL HEATING DRYOUT SERVICE</p> <p>Monthly Rate 38.573¢ per therm Minimum Monthly Bill - None</p>	<p><b>SCHEDULE 54</b> EMERGENCY INSTITUTIONAL SERVICE</p> <p>Monthly Rate 43.873¢ per therm Minimum Monthly Bill - None</p>

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 3  
 Date: 9/4/92  
 FILE: BIN ENERGY EST.

BUILDING 1 ANNUAL GAS USAGE FOR HEATING

BUILDING NO.: 1  
 PHASE : I  
 47°F HEAT LOSS = 1,462,000 BTUH  
 INTERNAL HEAT GAIN = 335,450 BTUH  
 CFM VENT = 18000.00 CFM  
 WALL = 18880.00 SF  
 WALL SW = 4000.00 SF  
 ROOF = 18650 SF  
 FLR = 570 LF

TEMP	T DIFF @ 70°F	HRS/YR	VENT MBH	WALL	ROOF	FLR	INTERNAL	TOTAL MBTU
67	3.00	581	59	17	2	1	335	0
62	8.00	1001	158	46	5	3	335	0
57	13.00	1316	257	74	8	5	335	12,650
52	18.00	1274	356	103	12	7	335	181,327
47	23.00	1271	455	132	15	9	335	349,582
42	28.00	1238	554	160	18	10	335	504,808
37	33.00	772	653	189	22	12	335	417,248
32	38.00	343	752	217	25	14	335	230,905
27	43.00	123	851	246	28	16	335	99,127
22	48.00	40	950	275	31	18	335	37,545
17	53.00	10	1049	303	35	20	335	10,713
12	58.00	4	1148	332	38	21	335	4,816
7	63.00	1	1247	360	41	23	335	1,337

THERMS BTU/SF/YR  
 TOTAL OUTPUT = 18,501 30,055  
 CENTRAL PLANT INPUT = 23,126 37,569  
 DECENTRAL PLANT INPUT = 19,474 31,637

Project: WSU VANCOUVER CAMPUS  
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Sheet No.: 4  
 Date: 9/4/92  
 FILE: BIN ENERGY EST.

**BUILDING 2 ANNUAL GAS USAGE FOR HEATING**

BUILDING NO.: 2  
 PHASE : I  
 47°F HEAT LOSS - 1,590,400 BTUH  
 INTERNAL HEAT GAIN - 281,820 BTUH  
 CFM VENT - 20850.00 CFM  
 WALL - 16800.00 SF  
 WALL SW - 4000.00 SF  
 ROOF - 16000 SF  
 FLR - 520 LF

TEMP	T DIFF	HRS/YR	VENT		WALL	ROOF	FLR	INTERNAL	TOTAL MBTU
			MBH						
67	3.00	581	69		16	2	1	282	0
62	8.00	1001	183		42	4	3	282	0
57	13.00	1316	298		68	7	4	282	125,821
52	18.00	1274	413		94	10	6	282	306,746
47	23.00	1271	528		120	13	8	282	490,528
42	28.00	1238	642		146	16	9	282	657,507
37	33.00	772	757		172	18	11	282	522,080
32	38.00	343	872		198	21	13	282	281,752
27	43.00	123	986		224	24	15	282	118,892
22	48.00	40	1101		250	27	16	282	44,471
17	53.00	10	1216		276	30	18	282	12,569
12	58.00	4	1330		302	32	20	282	5,608
7	63.00	1	1445		328	35	21	282	1,547

THERMS BTU/SF/YR  
 TOTAL OUTPUT - 25,675 49,375  
 CENTRAL PLANT INPUT - 32,094 61,719  
 DECENTRAL PLANT INPUT - 27,027 51,974

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 5  
 Date: 9/4/92  
 FILE: BIN ENERGY EST. 34

## BUILDING 3 ANNUAL GAS USAGE FOR HEATING

BUILDING NO.: 3  
 PHASE : I  
 47°F HEAT LOSS - 1,909,000 BTUH  
 INTERNAL HEAT GAIN - 454,760 BTUH  
 CFM VENT - 25740.00 CFM  
 WALL - 17200.00 SF  
 WALL SW - 4400.00 SF  
 ROOF - 17660 SF  
 FLR - 540 LF

TEMP	T DIFF	HRS/YR	VENT MBH	WALL	ROOF	FLR	INTERNAL	TOTAL MBTU
67	3.00	581	85	16	2	1	455	0
62	8.00	1001	227	43	5	3	455	0
57	13.00	1316	368	70	8	5	455	0
52	18.00	1274	510	97	11	6	455	215,989
47	23.00	1271	651	124	14	8	455	435,891
42	28.00	1238	793	151	17	10	455	639,262
37	33.00	772	934	178	20	12	455	532,512
32	38.00	343	1076	205	23	13	455	296,077
27	43.00	123	1218	232	27	15	455	127,503
22	48.00	40	1359	259	30	17	455	48,401
17	53.00	10	1501	286	33	19	455	13,834
12	58.00	4	1642	313	36	20	455	6,227
7	63.00	1	1784	340	39	22	455	1,730

THERMS BTU/SF/YR  
 TOTAL OUTPUT - 23,174 39,614  
 CENTRAL PLANT INPUT - 28,968 49,518  
 DECENTRAL PLANT INPUT - 24,394 41,699

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 6  
 Date: 9/4/92  
 FILE: BIN ENERGY EST. 34

BUILDING 4 ANNUAL GAS USAGE FOR HEATING

BUILDING NO.: 4  
 PHASE : I  
 47°F HEAT LOSS - 267,000 BTUH  
 INTERNAL HEAT GAIN - 53,000 BTUH  
 CFM VENT - 2790.00 CFM  
 WALL - 4040.00 SF  
 WALL SW - 1640.00 SF  
 ROOF - 4920 SF  
 FLR - 284 LF

TEMP	T DIFF	HRS/YR	VENT		WALL	ROOF	FLR	INTERNAL	TOTAL MBTU
			MBH						
67	3.00	581	9		4	1	1	53	0
62	8.00	1001	25		11	1	1	53	0
57	13.00	1316	40		18	2	2	53	13,154
52	18.00	1274	55		26	3	3	53	43,602
47	23.00	1271	71		33	4	4	53	74,294
42	28.00	1238	86		40	5	5	53	102,361
37	33.00	772	101		47	6	6	53	82,536
32	38.00	343	117		54	7	7	53	44,981
27	43.00	123	132		61	7	8	53	19,110
22	48.00	40	147		68	8	9	53	7,184
17	53.00	10	163		75	9	10	53	2,038
12	58.00	4	178		82	10	11	53	912
7	63.00	1	193		89	11	12	53	252

THERMS BTU/SF/YR  
 TOTAL OUTPUT - 3,904 48,803  
 CENTRAL PLANT INPUT - 4,880 61,004  
 DECENTRAL PLANT INPUT - 4,110 51,372

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 7  
 Date: 9/4/92  
 FILE: MECH HTG GAS COSTS

## CENTRAL PLANT HEATING COSTS

MONTH	OUTPUT MBH	INPUT THERMS	SCH. 3	SCH. 4
JAN	1,865,648	23,321	\$10,519	\$9,112
FEB	1,374,688	17,184	\$7,775	\$6,785
MAR	1,178,304	14,729	\$6,678	\$5,855
APR	981,920	12,274	\$5,580	\$4,924
MAY	687,344	8,592	\$3,934	\$3,513
JUN	0	0	\$7	\$797
JUL	0	0	\$7	\$797
AUG	0	0	\$7	\$797
SEP	196,384	2,455	\$1,191	\$1,057
OCT	589,152	7,364	\$3,386	\$3,034
NOV	1,276,496	15,956	\$7,227	\$6,320
DEC	1,669,264	20,866	\$9,421	\$8,181
<b>TOTAL:</b>	<b>9,819,200</b>	<b>122,740</b>	<b>\$55,733</b>	<b>\$51,173</b>
	<b>FUTURE VALUE TO 1998 =</b>		<b>\$69,150</b>	<b>\$63,493</b>

## NOTES:

1. Rate Schedule 3: 1st 10 th, \$7.14; next 290 th, \$0.54835/th;  
next 1,700 th, \$0.48312/th; add'l, \$0.44705/th
2. Rate Schedule 4: 1st 4000 th, \$0.43040/th; next 6,000 th, \$0.39015/th  
add'l, \$0.37905/th minimum bill of \$797.01/month
3. Boiler efficiency assumed to be 80%.

**PAE Consulting Engineers Inc.**

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851.00  
 Calc By: NPC

Sheet No.: 8  
 Date: 9/4/92  
 FILE: MECH HTG GAS COSTS

**DECENTRAL PLANTS HEATING COSTS - INDIVIDUAL METERS**

	BUILDING 1	BUILDING 2	BUILDING 3	BUILDING 4	BUILDING '5/6'	
MONTH	INPUT TH	INPUT TH	INPUT TH	INPUT TH	INPUT TH	
JAN	3,700	5,135	4,635	781	1,460	
FEB	2,726	3,784	3,415	575	1,076	
MAR	2,337	3,243	2,927	493	922	
APR	1,947	2,703	2,439	411	768	
MAY	1,363	1,892	1,708	288	538	
JUN	0	0	0	0	0	
JUL	0	0	0	0	0	
AUG	0	0	0	0	0	
SEP	389	541	488	82	154	
OCT	1,168	1,622	1,464	247	461	
NOV	2,532	3,514	3,171	534	999	
DEC	3,311	4,595	4,147	699	1,306	
<b>TOTAL:</b>	<b>19,474</b>	<b>27,027</b>	<b>24,394</b>	<b>4,110</b>	<b>7,683</b>	<b>82,688</b>
R.S. 3	\$9,455	\$12,874	\$11,683	\$2,180	\$3,915	\$40,105
<b>FUTURE VALUE TO 1998 =</b>						<b>\$49,761</b>

**DECENTRAL PLANTS HEATING COSTS - COMMON METER**

MONTH	OUTPUT MBH	INPUT THERMS	SCH. 3	SCH. 4
JAN	1,571,072	16,538	\$7,487	\$6,541
FEB	1,157,632	12,186	\$5,541	\$4,891
MAR	992,256	10,445	\$4,763	\$4,231
APR	826,880	8,704	\$3,984	\$3,557
MAY	578,816	6,093	\$2,817	\$2,538
JUN	0	0	\$7	\$797
JUL	0	0	\$7	\$797
AUG	0	0	\$7	\$797
SEP	165,376	1,741	\$862	\$797
OCT	496,128	5,222	\$2,428	\$2,199
NOV	1,074,944	11,315	\$5,152	\$4,561
DEC	1,405,696	14,797	\$6,708	\$5,881
<b>TOTAL:</b>	<b>8,268,800</b>	<b>87,040</b>	<b>\$39,764</b>	<b>\$37,586</b>
<b>FUTURE VALUE TO 1998 =</b>			<b>\$49,337</b>	<b>\$46,635</b>

**NOTES:**

1. Rate Schedule 3: 1st 10 th, \$7.14; next 290 th, \$0.54835/th;  
 next 1,700 th, \$0.48312/th; add'l, \$0.44705/th
2. Rate Schedule 4: 1st 4000 th, \$0.43040/th; next 6,000 th, \$0.39015/th  
 add'l, \$0.37905/th minimum bill of \$797.01/month
3. Boiler efficiency assumed to be 95%.



**APPENDIX C**  
**HEATING DISTRIBUTION PIPING SYSTEM COMPARISON**

**PAE Consulting Engineers Inc.**

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 1  
 Date: 9/4/92  
 FILE: BOILERS

**BOILER LOADS SUMMARY**

**DECENTRAL**

BUILDINGS	PHASE I			PHASE II		
	HTG LOAD	BOILER (MBH)	No. OF B.	HTG LOAD	BOILER (MBH)	No. OF B.
1	1465	843	3	85		
2	1590	843	3			
3	1910	843	4			
4	270	843	2			
'5/6	465	843	2			
'7/8				1065	843	2
				2820	843	4

**CENTRAL**

BUILDINGS	PHASE I			PHASE II		
	HTG LOAD	BOILER (MBH)	No. OF B.	HTG LOAD	BOILER (MBH)	No. OF B.
ALL	5700	2856	3	4000	2856	2

**MAINTENANCE COSTS PER YEAR**

ITEM	CENTRAL PLANT			DECENTRAL
	TUNNEL (\$)	PREFAB (\$)	DIRECT BURY (\$)	PLANT (\$)
BOILER (\$1000/B)	3000	3000	3000	9000
DISTRIBUTION PUMPING	2500	2500	2500	
DISTRIBUTION SYSTEM	200	300	500	
TOTALS	5700	5800	6000	9000

**PAE Consulting Engineers Inc.**

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 2  
 Date: 9/4/92  
 FILE: MECH EST. I

DESCRIPTION	QUANTITY	UNIT	PRICE	TOTAL PHASE I	QUAN.	TOTAL PHASE II
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**HEATING DISTRUBUTION INCREMENTAL COSTS**

**DIRECT BURY PIPING**

TRENCHING	2200	LF	9.55	21010	250	2387.5
DIRECT BURY PIPE 6"	2500	LF	80	200000		0
DIRECT BURY PIPE 4"	1900	LF	54	102600	250	13500
MANHOLE	4	EA	2500	10000		0

<b>SUBTOTAL -</b>				<b>\$333,610</b>		<b>\$15,888</b>
<b>1998 FUTURE VALUE @ 4%/YR -</b>				<b>\$413,926</b>		<b>\$19,712</b>

**PREFAB TRENCH**

PREFAB TRENCH	1250	LF	170	212500		0
DIRECT BURY TO BUILDINGS	950	LF	9.55	9072.5	250	2387.5
PIPE 6"	2500	LF	41	102500		0
6" PIPE INS 2" THICK	1900	LF	13.95	26505		0
DIRECT BURY PIPE 4"	2500	LF	54	135000	250	13500
MANHOLE	4	EA	2500	10000		0

<b>SUBTOTAL -</b>				<b>\$495,578</b>		<b>\$15,888</b>
<b>1998 FUTURE VALUE @ 4%/YR -</b>				<b>\$614,886</b>		<b>\$19,712</b>

**TUNNEL**

TUNNEL	2200	LF	315	693000	250	78750
PIPE 6"	2500	LF	41	102500		0
PIPE 4"	1900	LF	24	45600	250	6000
6" PIPE INS 2" THICK	2500	LF	13.95	34875		0
4" PIPE INS 2" THICK	1900	LF	11.6	22040	250	2900
MANHOLE	4	EA	2500	10000		0

<b>SUBTOTAL -</b>				<b>\$908,015</b>		<b>\$87,650</b>
<b>1998 FUTURE VALUE @ 4%/YR -</b>				<b>\$1,126,617</b>		<b>\$108,752</b>

**PAE Consulting Engineers Inc.**

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 3  
 Date: 9/4/92  
 FILE: MECH EST. I

DESCRIPTION	QUANTITY	UNIT	PRICE	TOTAL PHASE I	QUAN.	TOTAL PHASE II
<b>DECENTRAL PLANT INCREMENTAL HEATING COSTS</b>						0
1000 MBH BOILERS	14	EA	14000	196000	6	84000
BOILER SPACE REQUIREMENTS	1170	SF	80	93600	130	10400
GAS PIPE UPSIZE	2200	LF	4.5	9900	0	0
				0		0
<b>TOTAL =</b>				<b>\$299,500</b>		<b>\$94,400</b>
<b>1998 FUTURE VALUE @ 4%/YR =</b>				<b>\$371,604</b>		<b>\$117,127</b>

<b>CENTRAL PLANT INCREMENTAL HEATING COSTS</b>						0
2856 MBH BOILERS	3	EA	22700	68100	2	45400
BOILER SPACE REQUIREMENTS	1850	SF	40	74000		0
DISTRIBUTION PUMPING	1	TOT	26245	26245		0
<b>TOTAL =</b>				<b>\$168,345</b>		<b>\$45,400</b>
<b>1998 FUTURE VALUE @ 4%/YR =</b>				<b>\$208,874</b>		<b>\$56,330</b>

PAE Consulting Engineers Inc.

Project: WSU VANCOUVER CAMPUS

Job No.: 6851.00

Calc By: NPC

INTEREST = 8%

INFLATION = 4%

Sheet No.: 4

Date: 9/4/92

FILE: WSU MECH LAAC II

HEATING DISTRIBUTION SYSTEM LIFE CYCLE COST ANALYSIS

CENTRAL PLANT + TUNNEL				CENTRAL PLANT + PREFAB TRENCH				
	FIRST COSTS		ENERGY CONSUMPTION		MAINTENANCE COSTS		1998 VALUE	
	ITEM	VALUE	CONSUMPTION	MAINTENANCE	ITEM	CONSUMPTION	MAINTENANCE	VALUE
1998 VALUE		\$2,900,491			1998 VALUE			\$2,269,900
YR-1998	\$1,335,491	\$5,700	\$63,493	\$5,700	\$823,760	\$63,493	\$5,800	\$826,901
YR-1999		\$5,928	\$66,033	\$5,928		\$66,033	\$6,032	\$61,784
YR-2000		\$6,165	\$68,674	\$6,165		\$68,674	\$6,273	\$59,496
YR-2001		\$6,412	\$71,421	\$6,412		\$71,421	\$6,524	\$57,292
YR-2002		\$6,668	\$74,278	\$6,668		\$74,278	\$6,785	\$55,170
YR-2003		\$6,935	\$77,249	\$6,935		\$77,249	\$7,057	\$53,127
YR-2004		\$7,212	\$80,339	\$7,212		\$80,339	\$7,339	\$51,159
YR-2005		\$7,501	\$83,552	\$7,501		\$83,552	\$7,632	\$49,264
YR-2006		\$7,801	\$86,895	\$7,801		\$86,895	\$7,938	\$47,440
YR-2007		\$8,113	\$90,370	\$8,113		\$90,370	\$8,255	\$45,683
YR-2008		\$8,437	\$93,985	\$8,437		\$93,985	\$8,585	\$43,991
YR-2009		\$8,775	\$97,745	\$8,775		\$97,745	\$8,929	\$42,361
YR-2010	\$264,302	\$16,651	\$167,790	\$16,651	\$121,746	\$167,790	\$16,971	\$112,702
YR-2011		\$17,317	\$174,501	\$17,317		\$174,501	\$17,650	\$65,420
YR-2012		\$18,009	\$181,481	\$18,009		\$181,481	\$18,356	\$62,997
YR-2013		\$18,730	\$188,741	\$18,730		\$188,741	\$19,090	\$60,664
YR-2014		\$19,479	\$196,290	\$19,479		\$196,290	\$19,854	\$58,417
YR-2015		\$20,258	\$204,142	\$20,258		\$204,142	\$20,648	\$56,253
YR-2016		\$21,068	\$212,308	\$21,068		\$212,308	\$21,474	\$54,170
YR-2017		\$21,911	\$220,800	\$21,911		\$220,800	\$22,333	\$52,164
YR-2018		\$22,788	\$229,632	\$22,788		\$229,632	\$23,226	\$50,232
YR-2019		\$23,699	\$238,817	\$23,699		\$238,817	\$24,155	\$48,371
YR-2020		\$24,647	\$248,370	\$24,647		\$248,370	\$25,121	\$46,580
YR-2021		\$25,633	\$258,305	\$25,633		\$258,305	\$26,126	\$44,855
YR-2022		\$26,658	\$268,637	\$26,658		\$268,637	\$27,171	\$43,193
YR-2023		\$27,725	\$279,382	\$27,725		\$279,382	\$28,258	\$41,593
YR-2024		\$28,834	\$290,558	\$28,834		\$290,558	\$29,388	\$40,053
YR-2025		\$29,987	\$302,180	\$29,987		\$302,180	\$30,564	\$38,570

PAE Consulting Engineers Inc.

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851.00  
 Calc By: NPC  
 INTEREST - 8%  
 INFLATION - 4%  
 Sheet No.: 5  
 Date: 9/4/92  
 FILE: WSC MECH LAAC

HEATING CENTRAL PLANT/DECENTRAL PLANT LCCA

CENTRAL PLANT + DIRECT BURY				DECENTRAL PLANTS			
	FIRST COSTS ITEM	ENERGY CONSUMPTION MAINTENANCE COSTS	PRESENT VALUE	FIRST COSTS ITEM	ENERGY CONSUMPTION MAINTENANCE COSTS	PRESENT VALUE	
1998 VALUE			\$2,138,244	1998 VALUE		\$1,608,118	
YR-1998	\$622,800	\$63,493	\$6,000	\$371,604	\$46,635	\$9,000	\$423,118
YR-1999		\$66,033	\$6,240		\$48,500	\$9,360	\$49,606
YR-2000		\$68,674	\$6,490		\$50,440	\$9,734	\$47,769
YR-2001		\$71,421	\$6,749		\$52,458	\$10,124	\$45,999
YR-2002		\$74,278	\$7,019		\$54,556	\$10,529	\$44,296
YR-2003		\$77,249	\$7,300		\$56,739	\$10,950	\$42,655
YR-2004		\$80,339	\$7,592		\$59,008	\$11,388	\$41,075
YR-2005		\$83,552	\$7,896		\$61,368	\$11,843	\$39,554
YR-2006		\$86,895	\$8,211		\$63,823	\$12,317	\$38,089
YR-2007		\$90,370	\$8,540		\$66,376	\$12,810	\$36,678
YR-2008		\$93,985	\$8,881		\$69,031	\$13,322	\$35,320
YR-2009		\$97,745	\$9,237		\$71,792	\$13,855	\$34,012
YR-2010	\$121,746	\$167,790	\$17,611	\$187,524	\$123,239	\$22,414	\$128,025
YR-2011		\$174,501	\$18,316		\$128,169	\$23,311	\$51,573
YR-2012		\$181,481	\$19,048		\$133,296	\$24,243	\$49,663
YR-2013		\$188,741	\$19,810		\$138,628	\$25,213	\$47,824
YR-2014		\$196,290	\$20,603		\$144,173	\$26,222	\$46,052
YR-2015		\$204,142	\$21,427		\$149,940	\$27,271	\$44,347
YR-2016		\$212,308	\$22,284		\$155,937	\$28,361	\$42,704
YR-2017		\$220,800	\$23,175		\$162,175	\$29,496	\$41,123
YR-2018		\$229,632	\$24,102		\$168,662	\$30,676	\$39,600
YR-2019		\$238,817	\$25,066		\$175,408	\$31,903	\$38,133
YR-2020		\$248,370	\$26,069		\$182,424	\$33,179	\$36,721
YR-2021		\$258,305	\$27,112		\$189,721	\$34,506	\$35,361
YR-2022		\$268,637	\$28,196		\$197,310	\$35,886	\$34,051
YR-2023		\$279,382	\$29,324		\$205,203	\$37,322	\$32,790
YR-2024		\$290,558	\$30,497		\$213,411	\$38,815	\$31,575
YR-2025		\$302,180	\$31,717		\$221,947	\$40,367	\$30,406

**APPENDIX D**  
**COOLING DISTRIBUTION PIPING SYSTEM COMPARISON**

**PAE Consulting Engineers Inc.**

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 1  
 Date: 9/4/92  
 FILE: MECH EST. I

DESCRIPTION	QUANTITY	UNIT	PRICE	TOTAL PHASE I	QUAN.	TOTAL PHASE II
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**CENTRAL PLANT INCREMENTAL COOLING COSTS**

0

**DIRECT BURY PIPING**

TRENCHING	2200	LF	9.55	21010	250	2387.5
DIRECT BURY PIPE 12"	2500	LF	145	362500		0
DIRECT BURY PIPE 8"	1900	LF	94	178600	250	23500
MANHOLE	4	EA	2500	10000		0

**SUBTOTAL -**

**\$572,110**

**\$25,888**

**1998 FUTURE VALUE @ 4%/YR -**

**\$709,844**

**\$32,120**

**PREFAB TRENCH**

PREFAB TRENCH	1250	LF	170	212500		0
DIRECT BURY TO BUILDINGS	950	LF	9.55	9072.5	250	2387.5
PIPE 12"	2500	LF	67	167500		0
12" PIPE INS 2" THICK	2500	LF	25	62500		0
DIRECT BURY PIPE 8"	1900	LF	94	178600	250	23500
MANHOLE	4	EA	2500	10000		0

**SUBTOTAL -**

**\$640,173**

**\$25,888**

**1998 FUTURE VALUE @ 4%/YR -**

**\$794,292**

**\$32,120**

**TUNNEL**

TUNNEL	2200	LF	315	693000	250	78750
PIPE 12"	2500	LF	67	167500		0
PIPE 8"	1900	LF	46	87400	250	11500
12" PIPE INS 2" THICK	2500	LF	25	62500		0
8" PIPE INS 2" THICK	1900	LF	18.75	35625	250	4687.5
MANHOLE	4	EA	2500	10000		0

**SUBTOTAL -**

**\$1,056,025**

**\$94,938**

**1998 FUTURE VALUE @ 4%/YR -**

**\$1,310,260**

**\$117,793**



**PAE Consulting Engineers Inc.**

Project: WSU VANCOUVER CAMPUS

Job No.: 6851.00

Calc By: NPC

INTEREST - 8%

INFLATION - 48

Sheet No.:

Date: 9/4/92

FILE: WSC MECH LAAC CHW I

## COOLING

CENTRAL PLANT - DIRECT BURY				CENTRAL PLANT - TUNNEL			
	ENERGY		PRESENT VALUE	ENERGY		PRESENT VALUE	
	FIRST COSTS ITEM	CONSUMPTION MAINTENANCE COSTS		FIRST COSTS ITEM	CONSUMPTION MAINTENANCE COSTS		
1998 VALUE			\$771,530	1998 VALUE		\$1,401,075	
YR-1998	\$709,844	\$0	\$712,622	\$1,310,260	\$2,700	\$1,312,760	
YR-1999		\$0	\$2,675		\$0	\$2,407	
YR-2000		\$0	\$2,576		\$0	\$2,318	
YR-2001		\$0	\$2,480		\$0	\$2,232	
YR-2002		\$0	\$2,389		\$0	\$2,150	
YR-2003		\$0	\$2,300		\$0	\$2,070	
YR-2004		\$0	\$2,215		\$0	\$1,993	
YR-2005		\$0	\$2,133		\$0	\$1,920	
YR-2006		\$0	\$2,054		\$0	\$1,848	
YR-2007		\$0	\$1,978		\$0	\$1,780	
YR-2008		\$0	\$1,905		\$0	\$1,714	
YR-2009		\$0	\$1,834		\$0	\$1,651	
YR-2010	\$32,120	\$0	\$14,521	\$117,793	\$4,323	\$48,367	
YR-2011		\$0	\$1,701		\$0	\$1,531	
YR-2012		\$0	\$1,638		\$0	\$1,474	
YR-2013		\$0	\$1,577		\$0	\$1,419	
YR-2014		\$0	\$1,519		\$0	\$1,367	
YR-2015		\$0	\$1,462		\$0	\$1,316	
YR-2016		\$0	\$1,408		\$0	\$1,267	
YR-2017		\$0	\$1,356		\$0	\$1,220	
YR-2018		\$0	\$1,306		\$0	\$1,175	
YR-2019		\$0	\$1,257		\$0	\$1,132	
YR-2020		\$0	\$1,211		\$0	\$1,090	
YR-2021		\$0	\$1,166		\$0	\$1,049	
YR-2022		\$0	\$1,123		\$0	\$1,011	
YR-2023		\$0	\$1,081		\$0	\$973	
YR-2024		\$0	\$1,041		\$0	\$937	
YR-2025		\$0	\$1,003		\$0	\$902	

P&E Consulting Engineers Inc.

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851.00  
 Calc By: NPC  
 INTEREST = 8%  
 INFLATION = 4%

Sheet No.: 3  
 Date: 9/4/92  
 FILE: WSC MECH LAAC CHW II

COOLING

CENTRAL PLANT - PREFAB TUNNEL

	FIRST COSTS ITEM	ENERGY CONSUMPTION	MAINTENANCE COSTS	PRESENT VALUE	FIRST COSTS ITEM	ENERGY CONSUMPTION	MAINTENANCE COSTS	PRESENT VALUE
1998 VALUE				\$852,716	1998 VALUE			\$0
YR-1998	\$794,292	\$0	\$2,800	\$796,885				\$0
YR-1999		\$0	\$2,912	\$2,497			\$0	\$0
YR-2000		\$0	\$3,028	\$2,404			\$0	\$0
YR-2001		\$0	\$3,150	\$2,315			\$0	\$0
YR-2002		\$0	\$3,276	\$2,229			\$0	\$0
YR-2003		\$0	\$3,407	\$2,147			\$0	\$0
YR-2004		\$0	\$3,543	\$2,067			\$0	\$0
YR-2005		\$0	\$3,685	\$1,991			\$0	\$0
YR-2006		\$0	\$3,832	\$1,917			\$0	\$0
YR-2007		\$0	\$3,985	\$1,846			\$0	\$0
YR-2008		\$0	\$4,145	\$1,778			\$0	\$0
YR-2009		\$0	\$4,310	\$1,712			\$0	\$0
YR-2010	\$32,120		\$4,483	\$14,404	\$0		\$0	\$0
YR-2011		\$0	\$4,662	\$1,587			\$0	\$0
YR-2012		\$0	\$4,849	\$1,529			\$0	\$0
YR-2013		\$0	\$5,043	\$1,472			\$0	\$0
YR-2014		\$0	\$5,244	\$1,417			\$0	\$0
YR-2015		\$0	\$5,454	\$1,365			\$0	\$0
YR-2016		\$0	\$5,672	\$1,314			\$0	\$0
YR-2017		\$0	\$5,899	\$1,266			\$0	\$0
YR-2018		\$0	\$6,135	\$1,219			\$0	\$0
YR-2019		\$0	\$6,381	\$1,174			\$0	\$0
YR-2020		\$0	\$6,636	\$1,130			\$0	\$0
YR-2021		\$0	\$6,901	\$1,088			\$0	\$0
YR-2022		\$0	\$7,177	\$1,048			\$0	\$0
YR-2023		\$0	\$7,464	\$1,009			\$0	\$0
YR-2024		\$0	\$7,763	\$972			\$0	\$0
YR-2025		\$0	\$8,073	\$936			\$0	\$0

**APPENDIX E**  
**HYDRONIC HEAT PUMP ANALYSIS**

**PAE Consulting Engineers Inc.**

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 1  
 Date: 9/4/92  
 FILE: MECH EST. I

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL PHASE I	QUAN.	TOTAL PHASE II
<b>CENTRAL COOLING/DECENTRAL HEATING SYSTEM INCREMENTAL COSTS (1)</b>						
<b>BUILDING 1</b>						
SPACE REQUIREMENTS	225	SF	80	18000	0	0
BOILERS 1000 MBH	3	EA	14000	42000	0	0
GAS PIPE UPSIZE	365	LF	4.5	1643	0	0
<b>SUBTOTAL =</b>				<b>\$61,643</b>		<b>\$0</b>
<b>BUILDING 2</b>						
SPACE REQUIREMENTS	225	SF	80	18000	0	0
BOILERS 1000 MBH	3	EA	14000	42000	0	0
GAS PIPE UPSIZE	365	LF	4.5	1643	0	0
<b>SUBTOTAL =</b>				<b>\$61,643</b>		<b>\$0</b>
<b>BUILDING 3</b>						
SPACE REQUIREMENTS	300	SF	80	24000	0	0
BOILERS 1000 MBH	4	EA	14000	56000	0	0
GAS PIPE UPSIZE	365	LF	4.5	1643	0	0
<b>SUBTOTAL =</b>				<b>\$81,643</b>		<b>\$0</b>
<b>BUILDING 4</b>						
SPACE REQUIREMENTS	150	SF	80	12000	0	0
BOILERS 1000 MBH	2	EA	14000	28000	0	0
GAS PIPE UPSIZE	365	LF	4.5	1643	0	0
<b>SUBTOTAL =</b>				<b>\$41,643</b>		<b>\$0</b>
<b>BUILDING 5/6</b>						
SPACE REQUIREMENTS	150	SF	80	12000	150	12000
BOILERS 1000 MBH	2	EA	14000	28000	2	28000
GAS PIPE UPSIZE	365	LF	4.5	1643	0	0
<b>SUBTOTAL =</b>				<b>\$41,643</b>		<b>\$40,000</b>
<b>BUILDING 7/8</b>						
SPACE REQUIREMENTS	0	SF	80	0	300	24000
BOILERS 1000 MBH	0	EA	14000	0	4	56000
GAS PIPE UPSIZE	0	LF	4.5	0	365	1643
<b>SUBTOTAL =</b>				<b>\$0</b>		<b>\$81,643</b>

**PAE Consulting Engineers Inc.**

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 2  
 Date: 9/4/92  
 FILE: MECH EST. I

DESCRIPTION	QUANTITY	UNIT	PRICE	TOTAL PHASE I	QUAN.	TOTAL PHASE II
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**CENTRAL COOLING/DECENTRAL HEATING SYSTEM INCREMENTAL COSTS (1)**

**CENTRAL PLANT**

SPACE REQUIREMENTS	2500	SF	40	100000	0	0
CHILLERS 250 TON	3	EA	118400	355200	0	0
CHILLER 500 TON	0	EA	167500	0	1	167500
CHILLED WATER PUMPS 500 GPM	2	EA	1900	3800	0	0
CHILLED WATER PUMP 1000 GPM	1	EA	2225	2225	1	2225
EMERGENCY VENT. & DETECTION	1	UNIT	10000	10000	0	0
<b>SUBTOTAL -</b>				<b>\$471,225</b>		<b>\$169,725</b>

**CHILLED WATER DISTRIBUTION SYSTEM**

TRENCHING	2200	LF	9.55	21010	250	2387.5
DIRECT BURY PIPE 12"	2500	LF	145	362500	0	0
DIRECT BURY PIPE 8"	1900	LF	94	178600	250	23500
MANHOLE	4	EA	2500	10000	0	0
PUMPS 1000 GPM	3	EA	2225	6675	1	2225
<b>SUBTOTAL -</b>				<b>\$578,785</b>		<b>\$28,113</b>

<b>TOTAL -</b>	<b>\$1,338,223</b>	<b>\$319,480</b>
<b>1998 FUTURE VALUE @ 4%/YR -</b>	<b>\$1,660,396</b>	<b>\$396,394</b>

**NOTES:**

- ITEMS AND COSTS COMMON TO BOTH THE HEAT PUMP SYSTEM AND THE CENTRAL COOLING/DECENTRAL HEATING SYSTEM ARE NOT INCLUDED IN EITHER.

**PAE Consulting Engineers Inc.**

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 3  
 Date: 9/4/92  
 FILE: MECH EST. I

DESCRIPTION	QUANTITY	UNIT	PRICE	TOTAL PHASE I	QUAN.	TOTAL PHASE II
<b>HEAT PUMP SYSTEM INCREMENTAL COSTS (1)</b>						
<b>BUILDING 1</b>						
HP SPACE REQUIREMENTS	500	SF	80	40000	0	0
HP DOUBLE BUNDLE EVAP&COND 100T	2	EA	92160	184320	0	0
BLDG HTG WATER SYSTEM (2)	61555	SF	0.5	30778	0	0
EMERGENCY VENT & DETECTION	1	UNIT	7500	7500	0	0
<b>SUBTOTAL -</b>				<b>\$262,598</b>		<b>\$0</b>
<b>BUILDING 2</b>						
HP SPACE REQUIREMENTS	500	SF	80	40000	0	0
HP DOUBLE BUNDLE EVAP&COND 100T	2	EA	92160	184320	0	0
BLDG HTG WATER SYSTEM (2)	52000	SF	0.5	26000	11000	5500
EMERGENCY VENT & DETECTION	1	UNIT	7500	7500	0	0
<b>SUBTOTAL -</b>				<b>\$257,820</b>		<b>\$5,500</b>
<b>BUILDING 3</b>						
HP SPACE REQUIREMENTS	500	SF	80	40000	0	0
HP DOUBLE BUNDLE EVAP&COND 120T	2	EA	111000	222000	0	0
BLDG HTG WATER SYSTEM (2)	58500	SF	0.5	29250	0	0
EMERGENCY VENT & DETECTION	1	UNIT	7500	7500	0	0
<b>SUBTOTAL -</b>				<b>\$298,750</b>		<b>\$0</b>
<b>BUILDING 4</b>						
HP SPACE REQUIREMENTS	500	SF	80	40000	0	0
HP DOUBLE BUNDLE EVAP&COND 17T	2	EA	37500	75000	0	0
BLDG HTG WATER SYSTEM (2)	8000	SF	0.5	4000	1500	750
EMERGENCY VENT & DETECTION	1	UNIT	7500	7500	0	0
<b>SUBTOTAL -</b>				<b>\$126,500</b>		<b>\$750</b>
<b>BUILDING 5/6</b>						
HP SPACE REQUIREMENTS	500	SF	80	40000	0	0
HP DOUBLE BUNDLE EVAP&COND 27T	2	EA	47400	94800	0	0
HP DOUBLE BUNDLE EVAP&COND 58T	2	EA	65880	131760	0	0
BLDG HTG WATER SYSTEM (2)	18425	SF	0.5	9213	40600	20300
EMERGENCY VENT & DETECTION	1	UNIT	7500	7500	0	0
<b>SUBTOTAL -</b>				<b>\$283,273</b>		<b>\$20,300</b>

**PAE Consulting Engineers Inc.**

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 4  
 Date: 9/4/92  
 FILE: MECH EST. I

DESCRIPTION	QUANTITY	UNIT	PRICE	TOTAL PHASE I	QUAN.	TOTAL PHASE II
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**HEAT PUMP SYSTEM INCREMENTAL COSTS (1)**

**BUILDING 7/8**

HP SPACE REQUIREMENTS	0	SF	80	0	500	40000
HP DOUBLE BUNDLE EVAP&COND 275T	0	EA	244800	0	2	489600
BLDG HTG WATER SYSTEM (2)	0	SF	0.5	0	86250	43125
EMERGENCY VENT & DETECTION	1	UNIT	7500	7500	0	0
<b>SUBTOTAL -</b>				<b>\$7,500</b>		<b>\$572,725</b>

**CENTRAL PLANT**

SPACE REQUIREMENTS	2500	SF	40	100000	0	0
WATER TO WATER HT EXCHANGER	2	EA	26250	52500	1	26250
BOILERS 1000 MBH	7	EA	14000	98000	5	70000
BOILER PUMPS	7	EA	500	3500	0	0
<b>SUBTOTAL -</b>				<b>\$254,000</b>		<b>\$96,250</b>

**CONDENSER/EVAPORATOR WATER DISTRIBUTION SYSTEM**

TRENCHING	2200	LF	9.55	21010	250	2387.5
DIRECT BURY PIPE 16"	2500	LF	190	475000	0	0
DIRECT BURY PIPE 8"	1900	LF	94	178600	250	23500
MANHOLE	4	EA	2500	10000	0	0
PUMPS 1500 GPM	3	EA	2800	8400	0	0
<b>SUBTOTAL -</b>				<b>\$693,010</b>		<b>\$25,888</b>

<b>TOTAL -</b>	<b>\$2,183,450</b>	<b>\$721,413</b>
<b>1998 FUTURE VALUE @ 4%/YR -</b>	<b>\$2,709,110</b>	<b>\$895,091</b>

**NOTES:**

1. ITEMS AND COSTS COMMON TO BOTH THE HEAT PUMP SYSTEM AND THE CENTRAL COOLING/DECENTRAL HEATING SYSTEM ARE NOT INCLUDED IN EITHER.
2. ESTIMATED COST FOR LARGER HEATING WATER PIPING AND HEATING COILS RESULTING FROM THE LOWER HEATING WATER TEMPERATURE REQUIRED BY THE HEAT PUMP SYSTEM.

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 5  
 Date: 9/4/92  
 FILE: BIN ENERGY EST-CLG

## CENTRAL COOLING/DECENTRAL HEATING

BUILDING	SUMMARY CHART - COOLING	
	PHASE I	PHASE II
	KWH	KWH
1,2,3,4	12,224	61,876
5/6 (EST)	72,987	160,988
7/8 (EST)		341,664
TOTAL -	85,211	564,528
COST @ \$.05/KWH	\$4,261	\$28,226
FV TO 1998	\$5,286	\$35,022

BUILDING	SUMMARY CHART - HEATING	
	PHASE I THERMS	PHASE II THERMS
1	19,474	884
2	27,027	
3	24,394	
4	4,110	
5/6 (EST)	7,683	16,946
7/8 (EST)		35,965
TOTAL	82,688	53,796
COST	\$37,586	\$24,453
FV 1998	\$46,635	\$30,340

## TOTAL CENTRAL COOLING/DECENTRAL HEATING ENERGY CONSUMPTION COSTS

	PHASE I	PHASE II
FV 1998 -	\$46,635	\$65,362

## HEAT PUMP - HEATING AND COOLING

BUILDING	SUMMARY CHART - HEATING & COOLING			
	PHASE I		PHASE II	
	KWH	THERMS	KWH	THERMS
1,2,3,4	1,127,048	13,696	97,803	1,188
5/6 (EST)	115,366	1,402	254,462	3,092
7/8 (EST)			540,044	6,562
TOTAL -	1,242,414	15,097	892,309	10,843
COST (1) -	62,121	6,863	44,615	4,929
FV TO 1998	85,592		61,472	

NOTES: 1. ENERGY COSTS; \$.05/KWH, \$.4546/THERM



Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 6  
 Date: 9/4/92  
 FILE: BIN ENERGY EST-CLG

## CENTRAL PLANT COOLING

BUILDING NO.: 1,2,3,4  
 PHASE : I KW/TON = 0.7  
 47°F HEAT LOSS - 5,228,400 BTUH  
 INTERNAL HEAT GAIN - 3,550,000 BTUH  
 CFM VENT - 67380.00 CFM  
 WALL - 56920.00 SF  
 WALL SW - 14040.00 SF  
 ROOF - 57230 SF  
 FLR - 1914 LF

TEMP	T DIFF	HRS/YR	VENT MBH	WALL	SW WALL	ROOF	FLR	INTERNAL TOTAL	MBTU
97	22.00	7	1631	751	386	44	27	3550	44,726
92	17.00	21	1260	581	298	34	21	3550	120,627
87	12.00	52	889	410	211	24	15	3550	265,138
82	7.00	126	519	239	123	14	9	3550	561,137
77	2.00	206	148	68	35	4	2	3550	784,476
72	0.00	373	0	0	0	0	0	3550	1,324,150
67	-3.00	581	-222	-102	-53	-6	-4	3550	1,837,586
62	-8.00	1001	-593	-273	-140	-16	-10	3550	2,519,980
57	-13.00	1316	-964	-444	-228	-26	-16	3550	2,463,719
52	-18.00	1274	-1334	-615	-316	-36	-22	3550	1,562,932
47	-23.00	1271	-1705	-785	-404	-46	-29	3550	739,030
42	-28.00	1238	-2075	-956	-491	-56	-35	3550	0

KWH MMBTU  
 TOTAL = 713,038 12,224

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC

Sheet No.: 7  
 Date: 9/4/92  
 FILE: BIN ENERGY EST-HP

## HEAT PUMP HEATING AND COOLING

BUILDING NO.: 1,2,3,4  
 PHASE : I KW/TON = 1  
 47°F HEAT LOSS = 5,228,400 BTUH HGT OF REJECTION= 1.15  
 INTERNAL HEAT GAIN 3,550,000 BTUH  
 CFM VENT = 67380.00 CFM  
 WALL = 56920.00 SF  
 WALL SW = 14040.00 SF  
 ROOF = 57230 SF  
 FLR = 1914 LF

TEMP	T DIFF	HRS/YR	VENT MBH	WALL	SW WALL	ROOF	FLR	INTERNAL	TOTAL MBTU
97	22.00	7	1631	751	386	44	27	3550	44,726
92	17.00	21	1260	581	298	34	21	3550	120,627
87	12.00	52	889	410	211	24	15	3550	265,138
82	7.00	126	519	239	123	14	9	3550	561,137
77	2.00	206	148	68	35	4	2	3550	784,476
72	0.00	373	0	0	0	0	0	3550	1,324,150
67	-3.00	581	-222	-102	-53	-6	-4	3550	1,837,586
62	-8.00	1001	-593	-273	-140	-16	-10	3550	2,519,980
57	-13.00	1316	-964	-444	-228	-26	-16	3550	2,463,719
52	-18.00	1274	-1334	-615	-316	-36	-22	3550	1,562,932
47	-23.00	1271	-1705	-785	-404	-46	-29	3550	739,030
42	-28.00	1238	-2075	-956	-491	-56	-35	3550	-79,084
37	-33.00	772	-2446	-1127	-579	-66	-41	3550	-547,515
32	-38.00	343	-2816	-1298	-667	-76	-47	3550	-464,611
27	-43.00	123	-3187	-1469	-755	-86	-53	3550	-245,986
22	-48.00	40	-3558	-1639	-842	-96	-60	3550	-105,809
17	-53.00	10	-3928	-1810	-930	-106	-66	3550	-32,906
12	-58.00	4	-4299	-1981	-1018	-116	-72	3550	-15,744
7	-63.00	1	-4669	-2152	-1106	-126	-78	3550	-4,581

COOLING = 12,223,502

HEATING = 1,496,235

MBTU KWH THERM

COOLING = 12,223,502 1,018,625

HP HEATING (1) = 108,423

BOILER (2) = 13,696

TOTAL INPUT = 1,127,048 13,696

## NOTES:

1 (HEATING MBTU/(12 MBH/TON) x (KW/TON))/HEAT OF REJECTION = KWH

2 (HEATING MBTU/100 MBTU/THERM)/HEAT OF REJECTION = THERM

PAE Consulting Engineers Inc.

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: NPC  
 Sheet No.: 8  
 Date: 9/4/92  
 FILE: WSU MECH LAAC HP

INTEREST - 8%  
 INFLATION - 4%

HEATING DISTRIBUTION SYSTEM LOCA

CENTRAL COOLING/DECENTRAL HEATING

HEAT PUMP

	FIRST COSTS ITEM	ENERGY CONSUMPTION	MAINTENANCE COSTS	1998 VALUE	FIRST COSTS ITEM	ENERGY CONSUMPTION	MAINTENANCE COSTS	1998 VALUE
1998 VALUE				\$4,199,134	1998 VALUE			\$5,126,163
YR-1998	\$1,660,396	\$95,398	\$13,500	\$1,761,227		\$85,592	\$15,000	\$2,601,576
YR-1999		\$99,214	\$14,040	\$97,097		\$89,016	\$15,600	\$89,691
YR-2000		\$103,182	\$14,602	\$93,501		\$92,576	\$16,224	\$86,369
YR-2001		\$107,310	\$15,186	\$90,038		\$96,279	\$16,873	\$83,170
YR-2002		\$111,602	\$15,793	\$86,703		\$100,131	\$17,548	\$80,090
YR-2003		\$116,066	\$16,425	\$83,492		\$104,136	\$18,250	\$77,124
YR-2004		\$120,709	\$17,082	\$80,400		\$108,301	\$18,980	\$74,267
YR-2005		\$125,537	\$17,765	\$77,422		\$112,633	\$19,739	\$71,517
YR-2006		\$130,559	\$18,476	\$74,554		\$117,139	\$20,529	\$68,868
YR-2007		\$135,781	\$19,215	\$71,793		\$121,824	\$21,350	\$66,317
YR-2008		\$141,212	\$19,983	\$69,134		\$126,697	\$22,204	\$63,861
YR-2009		\$146,861	\$20,783	\$66,574		\$131,765	\$23,092	\$61,496
YR-2010	\$634,640	\$257,382	\$30,420	\$357,848	\$1,433,070	\$235,454	\$25,617	\$622,932
YR-2011		\$267,677	\$31,636	\$101,905		\$244,872	\$26,641	\$92,440
YR-2012		\$278,384	\$32,902	\$98,130		\$254,667	\$27,707	\$89,016
YR-2013		\$289,520	\$34,218	\$94,496		\$264,854	\$28,815	\$85,719
YR-2014		\$301,100	\$35,587	\$90,996		\$275,448	\$29,968	\$82,544
YR-2015		\$313,144	\$37,010	\$87,626		\$286,466	\$31,166	\$79,487
YR-2016		\$325,670	\$38,491	\$84,380		\$297,925	\$32,413	\$76,543
YR-2017		\$338,697	\$40,030	\$81,255		\$309,842	\$33,710	\$73,708
YR-2018		\$352,245	\$41,631	\$78,246		\$322,235	\$35,058	\$70,978
YR-2019		\$366,335	\$43,297	\$75,348		\$335,125	\$36,460	\$68,350
YR-2020		\$380,988	\$45,028	\$72,557		\$348,530	\$37,919	\$65,818
YR-2021		\$396,228	\$46,830	\$69,870		\$362,471	\$39,435	\$63,380
YR-2022		\$412,077	\$48,703	\$67,282		\$376,970	\$41,013	\$61,033
YR-2023		\$428,560	\$50,651	\$64,790		\$392,049	\$42,653	\$58,772
YR-2024		\$445,702	\$52,677	\$62,391		\$407,730	\$44,360	\$56,596
YR-2025		\$463,530	\$54,784	\$60,080		\$424,040	\$46,134	\$54,500

**APPENDIX F**  
**COMBINED TUNNEL ANALYSIS**

PAE Consulting Engineers Inc.

Project: WSU VANCOUVER CAMPUS  
 Job No.: 6851  
 Calc By: JPG

Sheet No.: 1  
 Date: 9/4/92  
 FILE: DUCT/UTILIDOR COMP

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST
<b>INDIVIDUAL DUCTBANK SYSTEM</b>				
Emergency Distribution System				
Pullbox, 4x4x4	5	ea	1475.00	7375
Pullbox, 6x6x7	1	ea	2450.00	2450
Ductbank, 6-cell	1500	lf	30.00	45000
4-250 MCM: Bldgs 1,4	1300	lf	7.00	9100
4-#3: Bldgs 2,3,Ph II	2500	lf	4.80	12000
<b>Sub Total</b>				<b>\$75,925</b>
Communications Provisions				
Pullbox, 4x4x4	5	ea	1475.00	7375
Pullbox, 6x6x7	1	ea	2450.00	2450
Ductbank, 6-cell	1500	lf	30.00	45000
<b>Sub Total</b>				<b>\$54,825</b>
15KV Primary Distribution				
Pullbox, 4x4x4	5	ea	1475.00	7375
Pullbox, 6x6x7	1	ea	2450.00	2450
Ductbank, 6-cell	1500	lf	30.00	45000
15KV Primary Feeder	3000	lf	10.35	31050
<b>Sub Total</b>				<b>\$85,875</b>
<b>Total</b>				<b>\$216,625</b>
<b>Manufactured Tunnel System (Tunnel By Mechanical)</b>				
Emergency Distribution System				
Cable Tray	1500	ea	15.00	22500
4-250 MCM: Bldgs 1,4	1300	lf	8.45	10985
4-#3: Bldgs 2,3,Ph II	2500	lf	6.05	15125
<b>Sub Total</b>				<b>\$48,610</b>
Communications Provisions				
Cable Tray	1500	ea	15.00	22500
<b>Sub Total</b>				<b>\$22,500</b>
15KV Primary Distribution - NOTE: Installation of primary distribution will require "buildouts" of the tunnel wall at regular intervals to accomodate bending radius limitatations.				
Cable Tray	1500	ea	15.00	22500
15KV Primary Feeder	2500	lf	12.00	30000
<b>Sub Total</b>				<b>\$52,500</b>
<b>Total</b>				<b>\$123,610</b>

**PAE Consulting Engineers Inc.**

Project: WSU VANCOUVER CAMPUS  
Job No.: 6851  
Calc By: NPC

Sheet No.: 2  
Date: 9/4/92  
FILE: MECH EST. I

DESCRIPTION	QUANTITY	UNIT	PRICE	TOTAL PHASE I	QUAN.	TOTAL PHASE II
<b>CENTRAL PLANT INCREMENTAL COOLING COSTS</b>						0
<b>DIRECT BURY PIPING</b>						
TRENCHING	2200	LF	9.55	21010	250	2387.5
DIRECT BURY PIPE 12"	2500	LF	145	362500		0
DIRECT BURY PIPE 8"	1900	LF	94	178600	250	23500
MANHOLE	4	EA	2500	10000		0
<b>SUBTOTAL =</b>				<b>\$572,110</b>		<b>\$25,888</b>
<b>1998 FUTURE VALUE @ 4%/YR =</b>				<b>\$709,844</b>		<b>\$32,120</b>
<b>TUNNEL</b>						
TUNNEL	2200	LF	315	693000	250	78750
PIPE 12"	2500	LF	67	167500		0
PIPE 8"	1900	LF	46	87400	250	11500
12" PIPE INS 2" THICK	2500	LF	25	62500		0
8" PIPE INS 2" THICK	1900	LF	18.75	35625	250	4687.5
MANHOLE	4	EA	2500	10000		0
ELECTRICAL CREDIT	1	UNIT	-93015	-93015	-9491	-9491
<b>SUBTOTAL =</b>				<b>\$963,010</b>		<b>\$85,447</b>
<b>1998 FUTURE VALUE @ 4%/YR =</b>				<b>\$1,194,852</b>		<b>\$106,018</b>

Project: MSU VANCOUVER CAMPUS  
Job No.: 6851.00

Calc By: NPC

INTEREST = 8%  
INFLATION = 4%

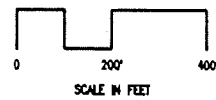
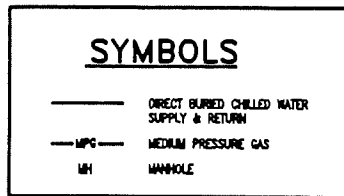
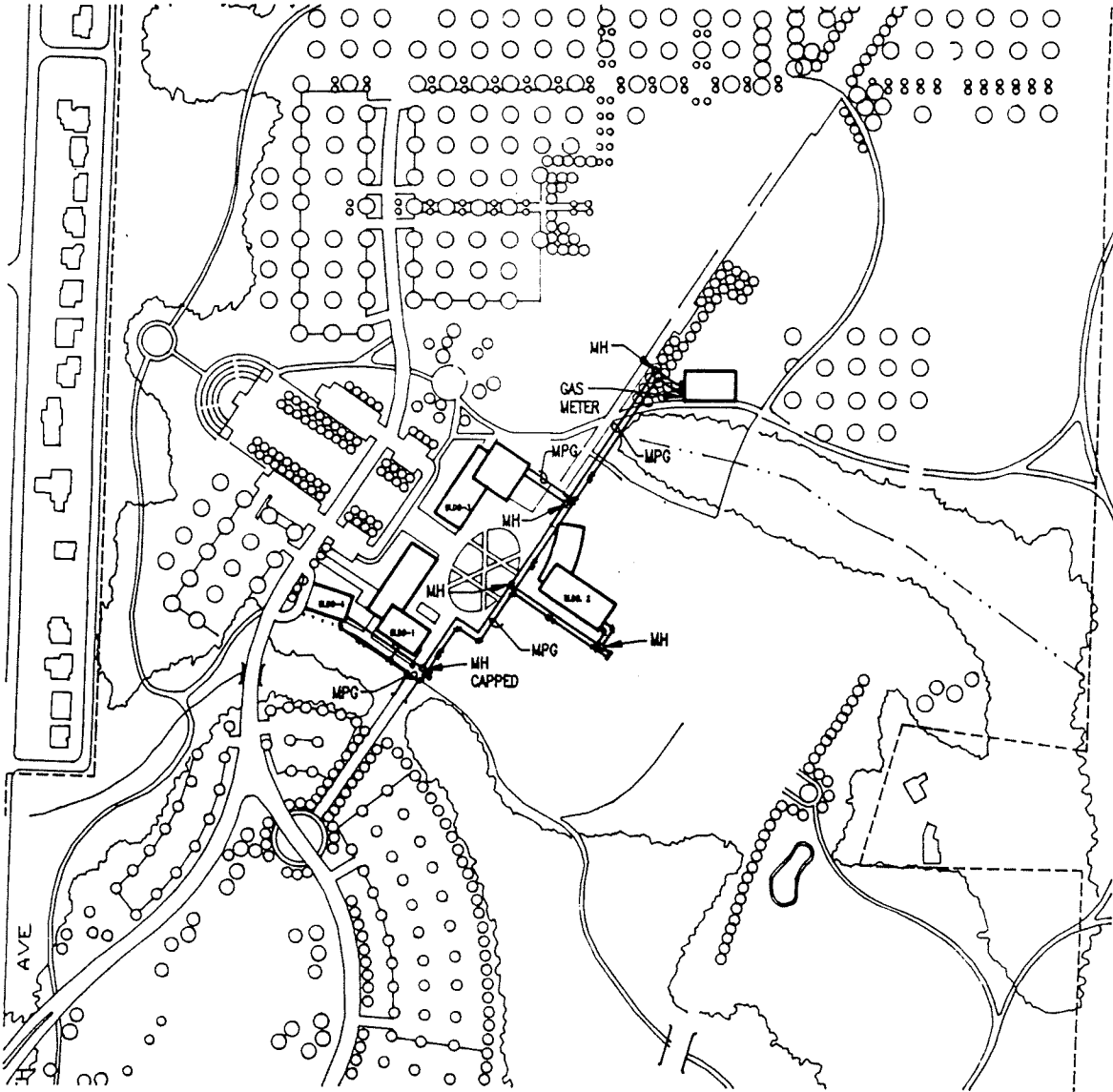
Sheet No.: 3

Date: 9/4/92

FILE: WSC MECH LAAC CHW I

## COOLING

CENTRAL PLANT - DIRECT BURY				CENTRAL PLANT - TUNNEL			
	FIRST COSTS ITEM	ENERGY CONSUMPTION MAINTENANCE COSTS	PRESENT VALUE	FIRST COSTS ITEM	ENERGY CONSUMPTION MAINTENANCE COSTS	PRESENT VALUE	
<b>1998 VALUE</b>			<b>\$771,530</b>	<b>1998 VALUE</b>		<b>\$1,280,991</b>	
YR-1998	\$709,844	\$0	\$3,000	\$1,194,852	\$2,700	\$1,197,352	
YR-1999		\$0	\$3,120		\$2,808	\$2,407	
YR-2000		\$0	\$3,245		\$2,920	\$2,318	
YR-2001		\$0	\$3,375		\$3,037	\$2,232	
YR-2002		\$0	\$3,510		\$3,159	\$2,150	
YR-2003		\$0	\$3,650		\$3,285	\$2,070	
YR-2004		\$0	\$3,796		\$3,416	\$1,993	
YR-2005		\$0	\$3,948		\$3,553	\$1,920	
YR-2006		\$0	\$4,106		\$3,695	\$1,848	
YR-2007		\$0	\$4,270		\$3,843	\$1,780	
YR-2008		\$0	\$4,441		\$3,997	\$1,714	
YR-2009		\$0	\$4,618		\$4,157	\$1,651	
YR-2010	\$32,120	\$0	\$4,803	\$106,019	\$4,323	\$43,691	
YR-2011		\$0	\$4,995		\$4,496	\$1,531	
YR-2012		\$0	\$5,195		\$4,676	\$1,474	
YR-2013		\$0	\$5,403		\$4,863	\$1,419	
YR-2014		\$0	\$5,619		\$5,057	\$1,367	
YR-2015		\$0	\$5,844		\$5,259	\$1,316	
YR-2016		\$0	\$6,077		\$5,470	\$1,267	
YR-2017		\$0	\$6,321		\$5,688	\$1,220	
YR-2018		\$0	\$6,573		\$5,916	\$1,175	
YR-2019		\$0	\$6,836		\$6,153	\$1,132	
YR-2020		\$0	\$7,110		\$6,399	\$1,090	
YR-2021		\$0	\$7,394		\$6,655	\$1,049	
YR-2022		\$0	\$7,690		\$6,921	\$1,011	
YR-2023		\$0	\$7,998		\$7,198	\$973	
YR-2024		\$0	\$8,317		\$7,486	\$937	
YR-2025		\$0	\$8,650		\$7,785	\$902	

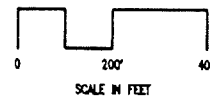
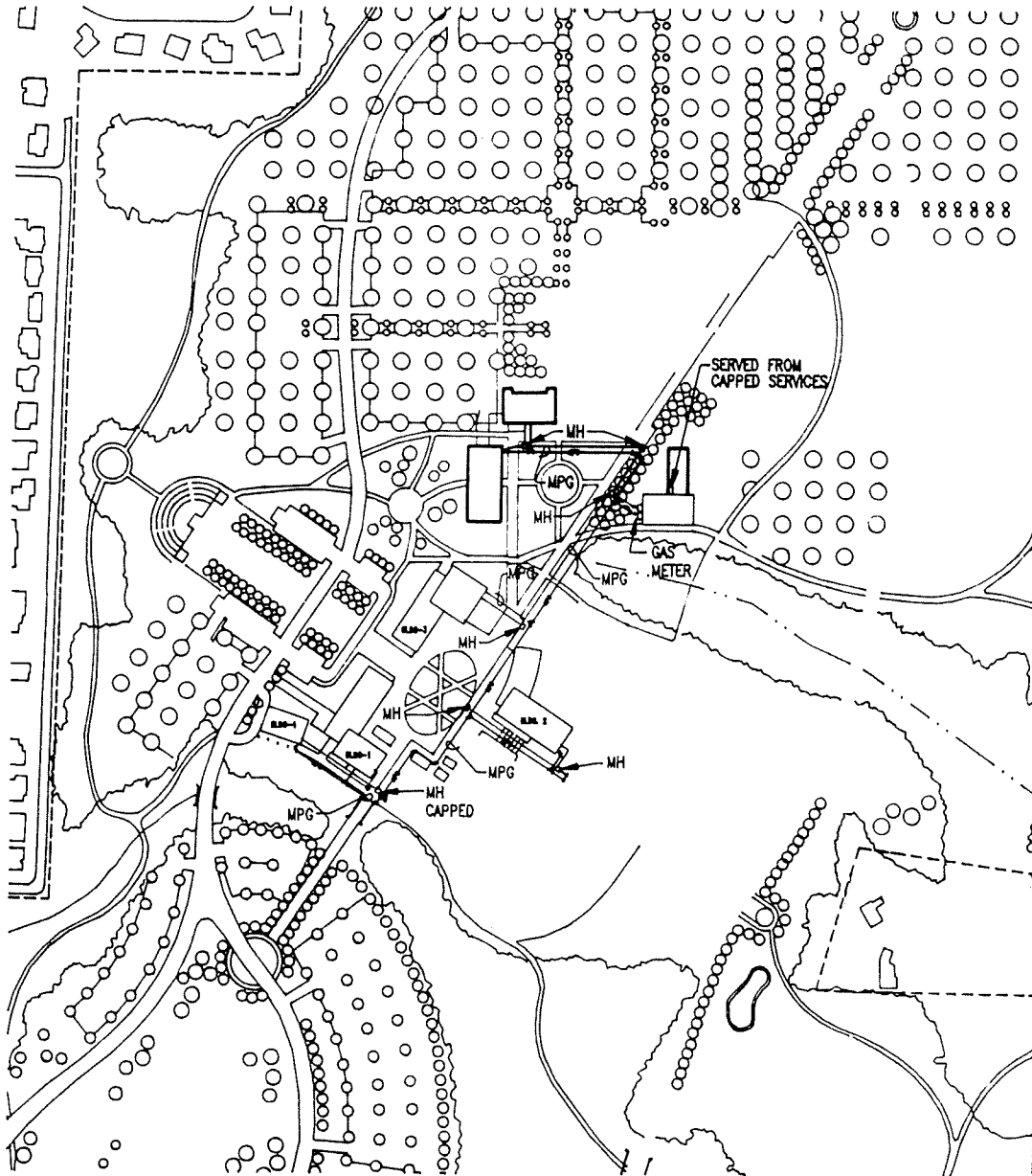


## **PHASE I DEVELOPMENT MECHANICAL MASTER PLAN**

**PAE**  
PAE Consulting Engineers Inc.

808 S.W. 3rd Avenue  
Portland, Oregon  
97204-2428  
503/228-2921

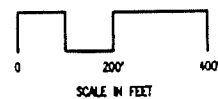
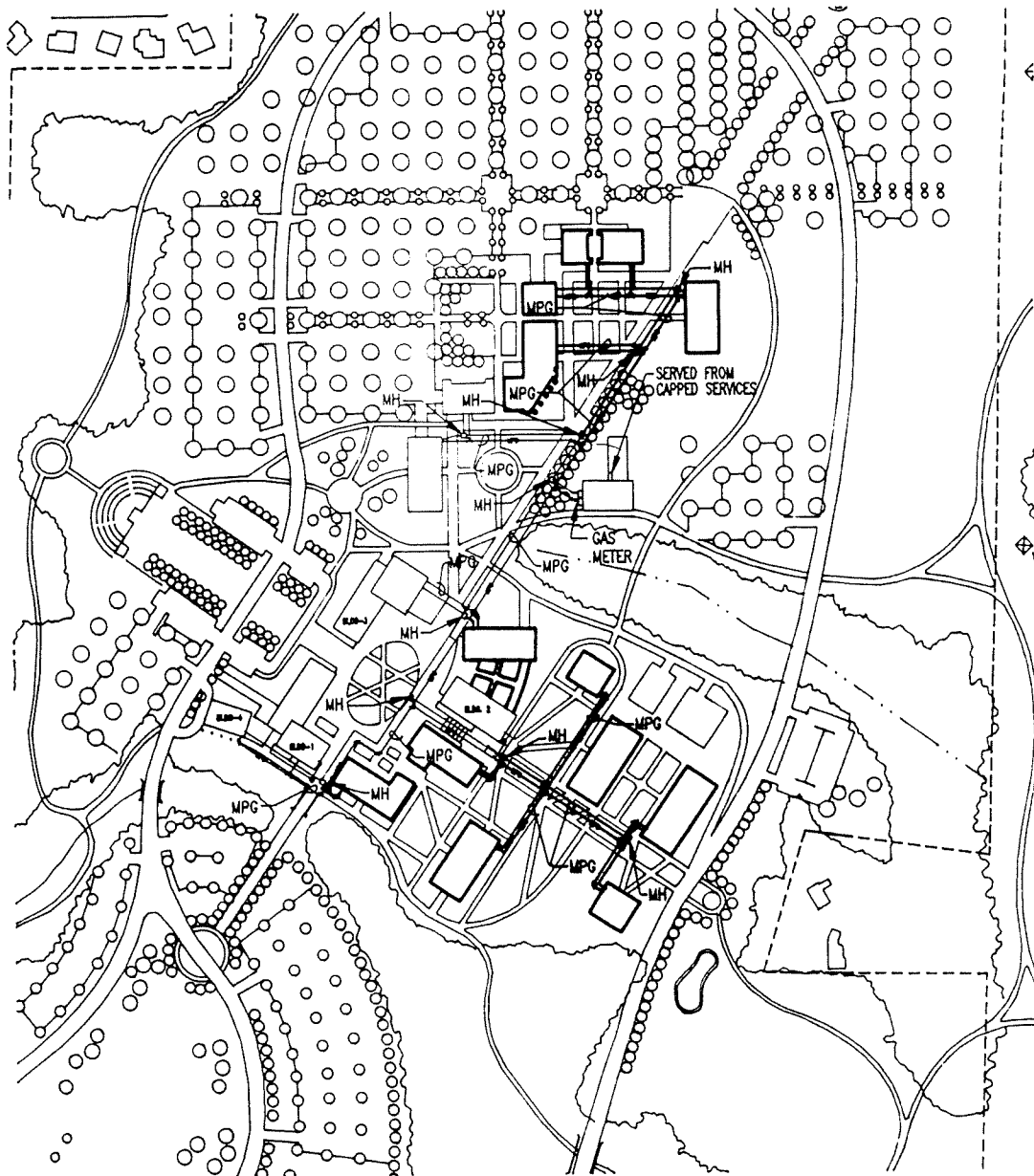




## PHASE II DEVELOPMENT MECHANICAL MASTER PLAN

**PAE**  
PAE Consulting Engineers Inc.

808 S.W. 3rd Avenue  
Portland, Oregon  
97204-2426  
503/226-2921



## PHASE III DEVELOPMENT MECHANICAL MASTER PLAN

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PAE Consulting Engineers Inc.

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Portland, Oregon  
97204-2426  
503/228-2921

**WASHINGTON STATE UNIVERSITY  
CAMPUS MASTER PLAN**

**TRANSPORTATION TECHNICAL REPORT**

**Prepared for:**

**ZIMMER, GUNSUL, FRASCA**

**Prepared by:**

**KIMLEY-HORN and ASSOCIATES, INC.**

WASHINGTON STATE UNIVERSITY  
CAMPUS MASTER PLAN

TRANSPORTATION TECHNICAL REPORT

Prepared for:

Zimmer, Gunsul, Frasca  
320 S.W. Oak Street, Suite 500  
Portland, Oregon 97204

Prepared by:

KIMLEY-HORN AND ASSOCIATES, INC.  
319 S.W. Washington Street, Suite 905  
Portland, Oregon 97204  
(503) 227-1666

July, 1992

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## SECTION I

### INTRODUCTION

#### PURPOSE AND OVERVIEW OF THIS REPORT

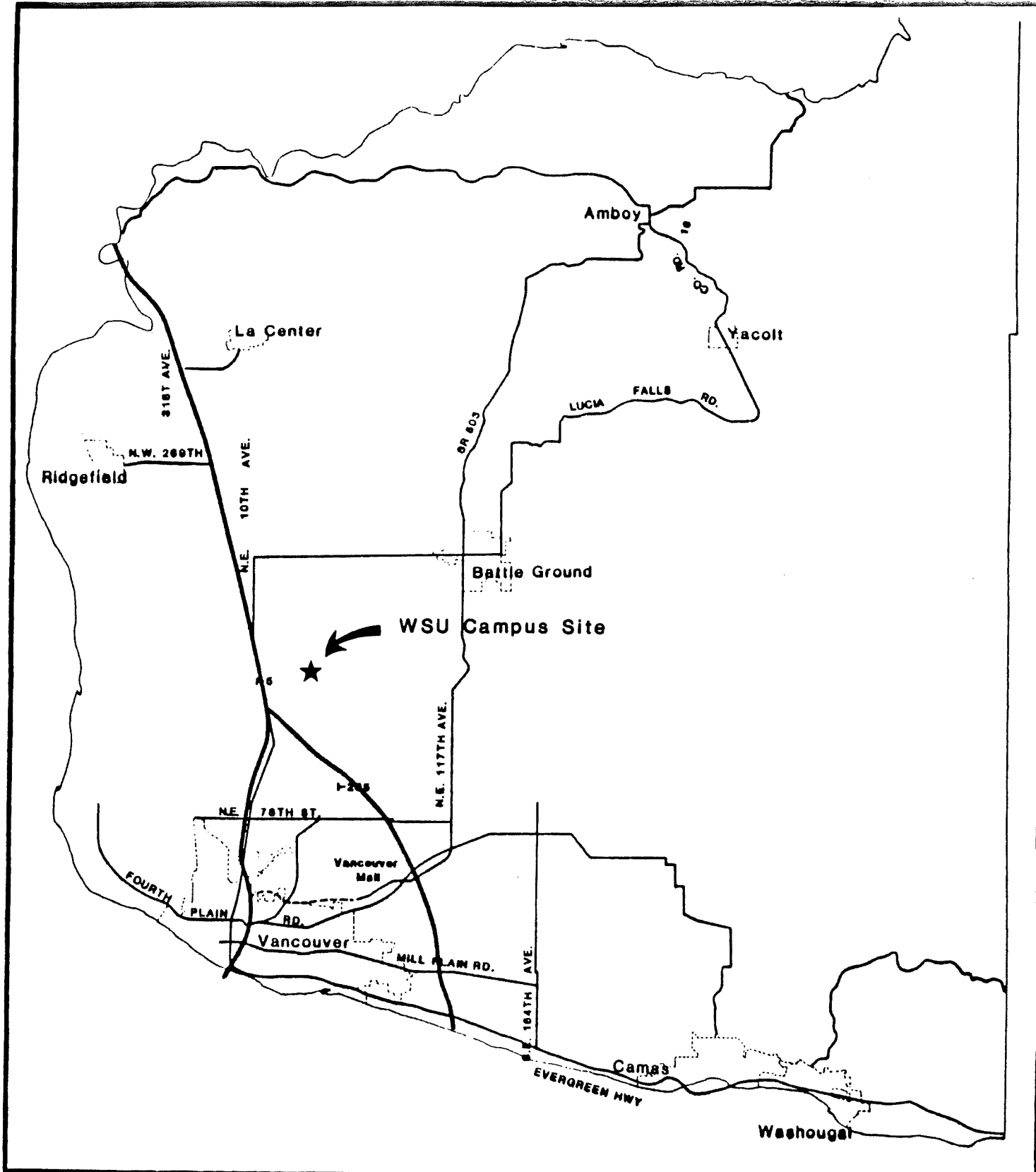
This report has been prepared to identify and document the traffic-related impacts attributable to development of the Washington State University Salmon Creek Campus located in Clark County, Washington. This report has been prepared in conformance with the requirements of Clark County and will generally address the following issues:

- Existing and future background traffic conditions in the study area (excluding WSU-related traffic);
- Identification of pending roadway improvements which affect accessibility to the campus site;
- Traffic volumes attributable to phased development of the campus;
- A comprehensive assessment of campus access alternatives and their associated roadway and intersection impacts;
- Identification of appropriate roadway improvements to mitigate the identified traffic impacts of each access alternative; and
- Discussion of potential measures which could be implemented to reduce vehicular travel demand to/from the campus.

This report is intended to serve as an appendix to the Supplemental Environmental Impact Statement presently being prepared for the campus.

#### PROJECT DESCRIPTION

The Washington State University (WSU) Vancouver Campus is located on 350 acres approximately 8 miles north of the Vancouver city center. Regional access to the campus site is provided by Interstate 5 and Interstate 205. Access to the County road and street system is available at interchanges with N.E. 134th Street and N.E. 179th Street, located southwest and northwest of the campus site, respectively. Direct access to the campus is available from Salmon Creek Avenue, N.E. 29th Avenue and N.E. 50th Avenue. The regional setting of the campus is shown in Figure 1. Figure 2 depicts the general vicinity of the WSU campus site including the surrounding street system.

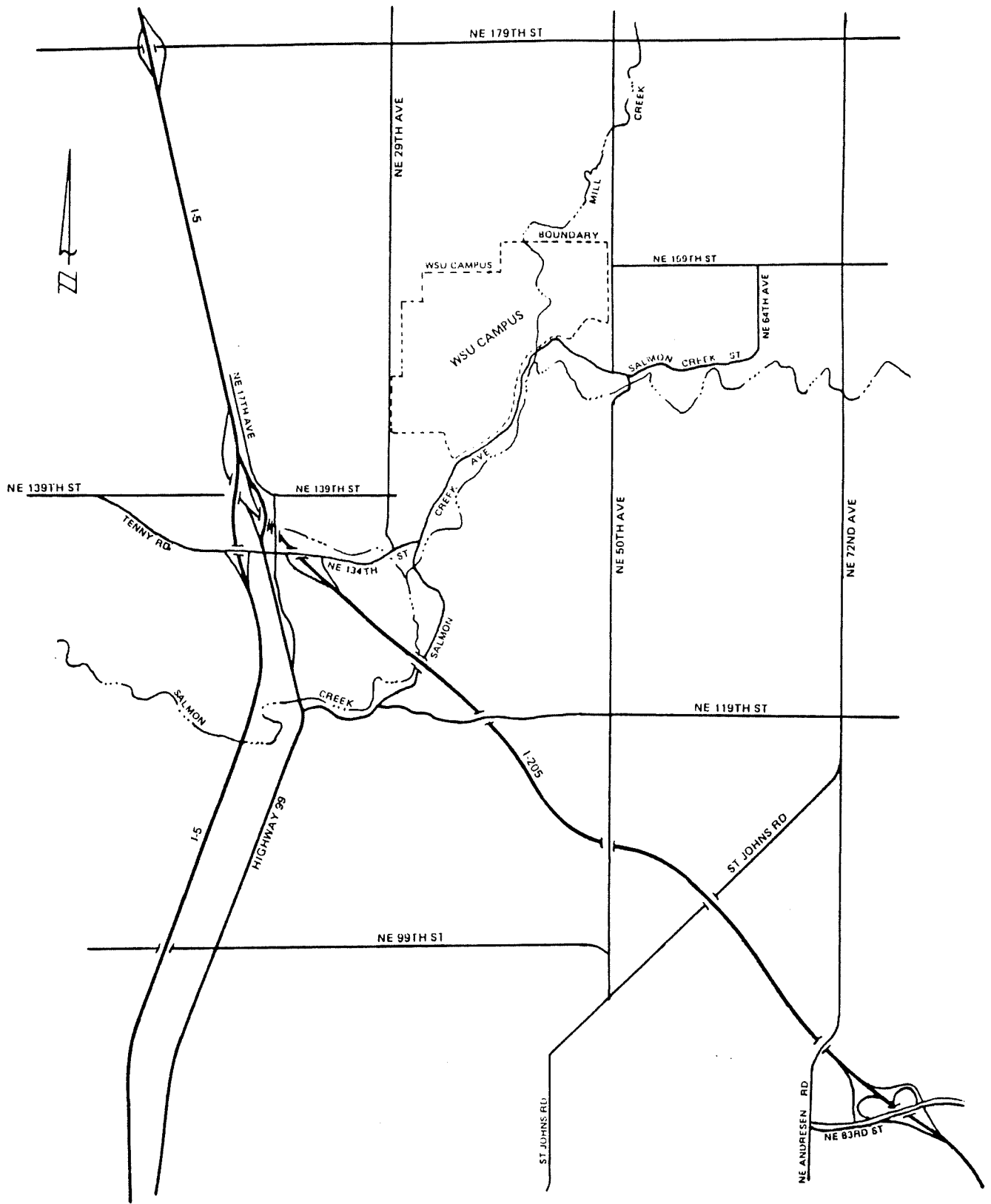


**Kimley-Horn**

Kimley-Horn and Associates, Inc.

**FIGURE 1**

**REGIONAL SETTING OF WSU CAMPUS**



**Kimley-Horn**

Kimley-Horn and Associates, Inc.

**FIGURE 2**

**VICINITY MAP FOR WSU CAMPUS**

The WSU campus site will develop in phases consistent with the educational opportunities and infrastructure provided. The first phase of campus development is expected to be complete by 1998. At that time, the campus will serve a total head count of 2,414 students. Phase II is expected to be complete by 2010 and to have a total head count of 4,310 students. Phase III completion is projected to occur in 2025, at which time there will be a total head count of 8,600 students.

These phases will have a significant impact on transportation demand associated with the campus. The short-term impacts associated with Phase I development in 1998 and long-term impacts associated with Phase II development in 2010 will be analyzed. Phase III development will occur by 2025, over 30 years in the future. The time frame is beyond the planning horizon of Clark County and no projections of land use and/or transportation demand are available. Accordingly, no analysis of traffic impacts associated with Phase III will be prepared.

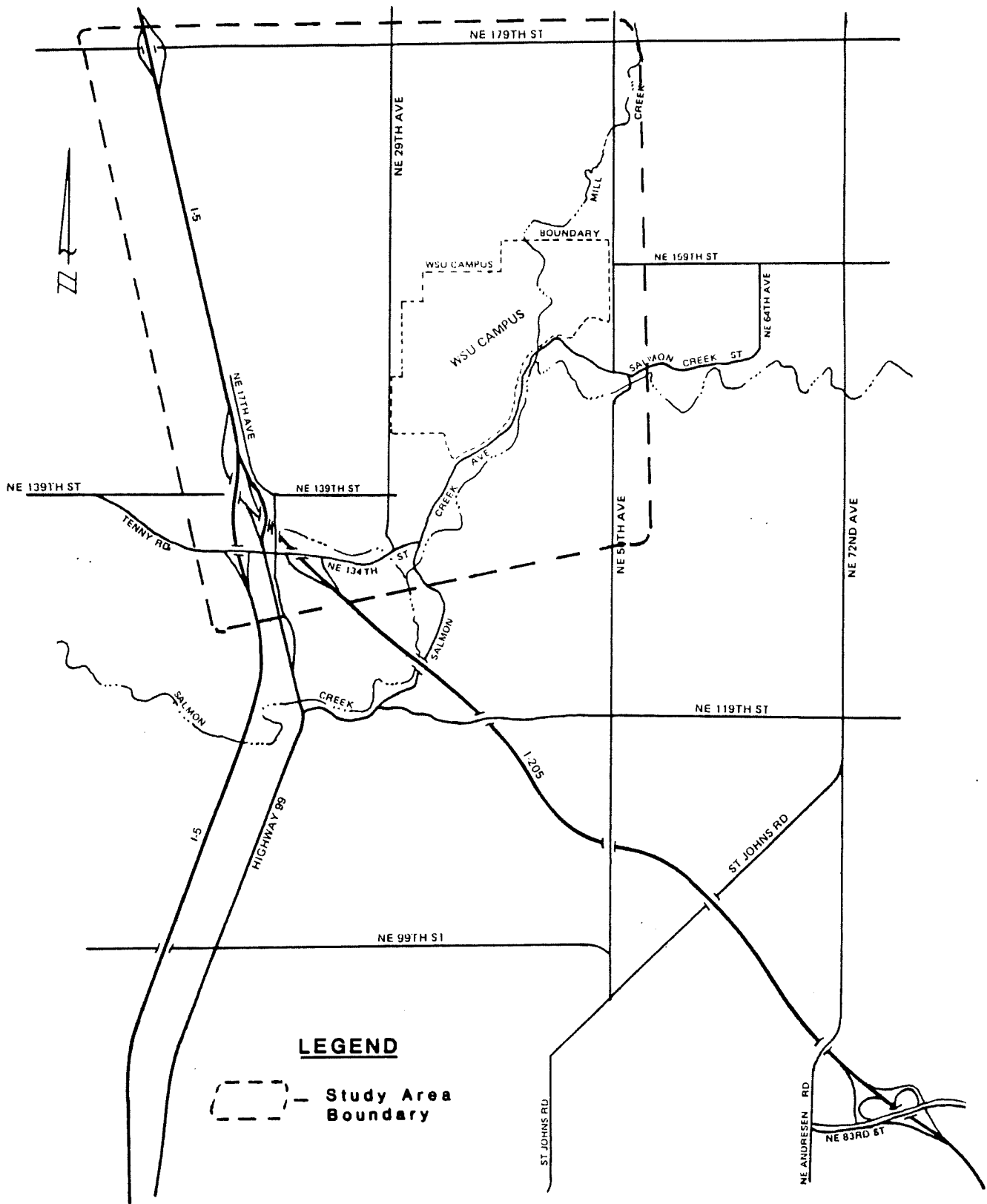
## **STUDY AREA**

The study area which forms of focus of transportation analysis for the WSU campus is presented in Figure 3. This area is generally bounded by and includes N.E. 179th Street on the north, N.E. 50th Avenue on the east, Interstate 5 on the west and N.E. 134th Street on the south.

## **REPORT CONTENT AND ORGANIZATION**

This report is organized into five sections, the first of which is this Introduction. Section II documents existing transportation conditions within the WSU study area including characteristics of the street and highway system, existing traffic volumes and levels of service, accident history, and existing public and school transit service.

Section III presents a forecast and analysis of future background traffic conditions for 1998 and 2010. Traffic attributable to the WSU campus is specifically not included in these forecasts in order that the impact of non-campus traffic and associated necessary roadway improvements may be identified. The projections presented in this Section will form the basis for identifying the impact of WSU-related traffic when the campus is developed.



**Kimley-Horn**

Kimley-Horn and Associates, Inc.

**FIGURE 3**  
**WSU CAMPUS**  
**TRANSPORTATION STUDY AREA**



In Section IV, traffic impacts attributable to the WSU campus are identified and discussed. The primary focus of this section is to develop and present as wide a range of campus access alternatives as possible and to identify the associated traffic impacts of each. This analysis is intended to facilitate identification of the most desirable and appropriate location for campus access and associated roadway and intersection improvement requirements.

Section V includes discussion of the mitigation measures necessary with each access alternative to ensure that an acceptable level of service is maintained at all key intersections in the project area. Specific roadway and intersection improvements are identified for both Phase I (1998) and Phase II (2010) of campus development. Section V also contains a discussion of transportation demand management strategies which might be implemented to reduce the demand for vehicular travel to/from the campus.

## SECTION II

### EXISTING CONDITIONS

Section II describes the existing transportation system, consisting of facilities and services, in the vicinity of the WSU campus site. Issues to be specifically addressed include:

- Description of the existing street and highway system in the study area and analysis of current traffic volumes and operations;
- Current accident experience on streets in the study area; and
- Existing public transportation service including that provided by C-TRAN and by the Vancouver and Battle Ground School Districts.

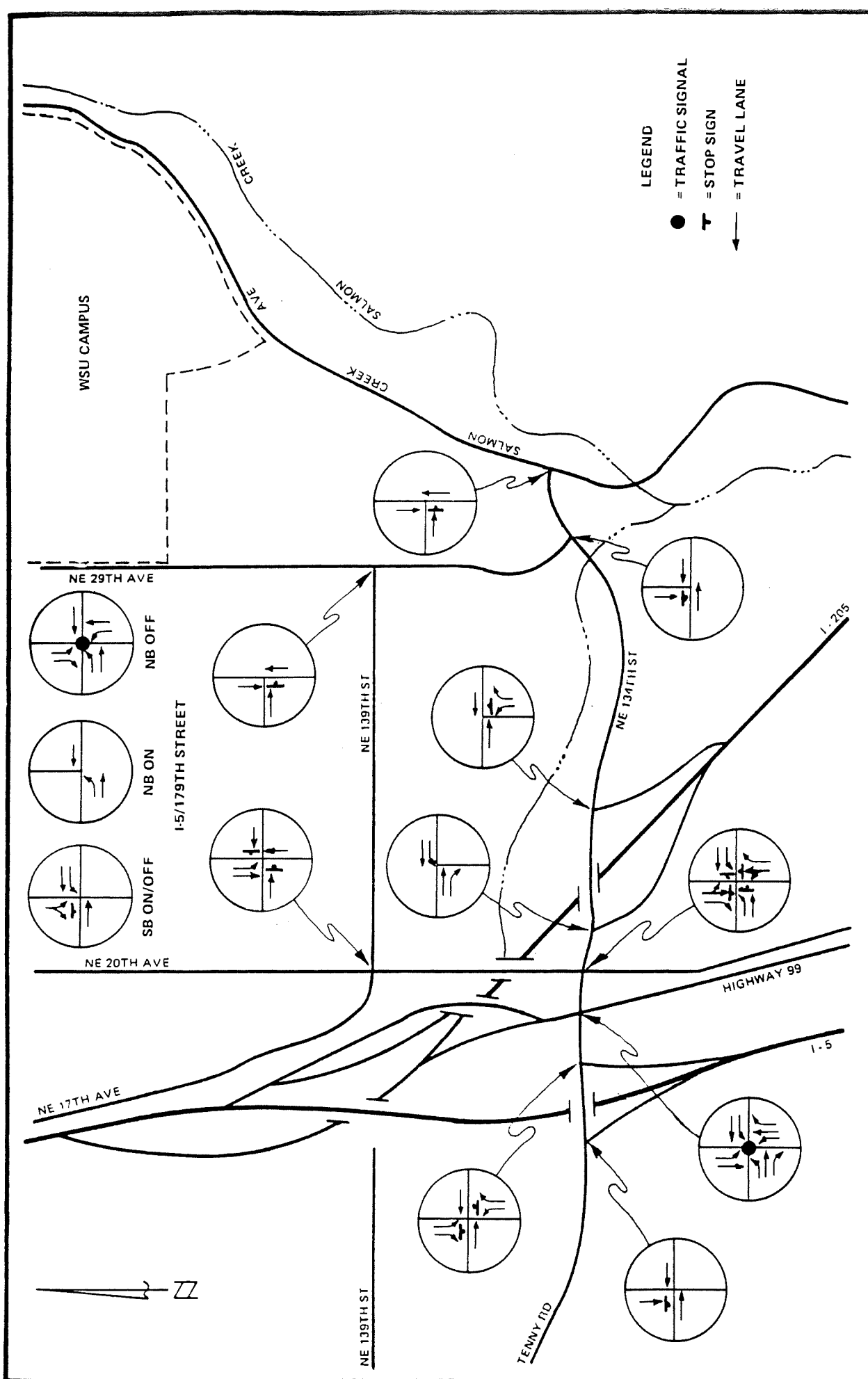
### EXISTING ROADWAY CHARACTERISTICS

Figures 4 and 5 identify major characteristics of the existing street and highway system within the study area. In Figure 4, features identified include current street classifications in accordance with the County's Comprehensive Plan, number of through lanes, posted speed limits and pavement width. In Figure 5, existing through and turning lanes and current traffic control at key intersections are depicted. The major features of these streets and highways are discussed in the following paragraphs.

Interstate 5 (I-5) is major north-south freeway linking the study area to the City of Vancouver and the Portland Metropolitan area on the south and to Longview/Kelso and the remainder of Western Washington on the north. In the study area, I-5 currently has two travel lanes in each direction and interchanges at N.E. 134th and N.E. 179th Streets.

Interstate 205 (I-205) is a major north-south freeway linking the study area to the eastern half of Clark County and the Portland Metropolitan area. I-205 is connected to I-5 at the northern and southern ends of the metropolitan area and is used as a bypass route for motorists who wish to avoid the congested I-5 Corridor. In the study area, I-205 currently has two travel lanes in each direction and an interchange at N.E. 134th Street. I-205 joins I-5 immediately north of N.E. 134th Street.





**FIGURE 5**

**EXISTING LANES AND TRAFFIC CONTROL AT KEY INTERSECTIONS**

**Kimley-Horn**

N.E. 134th Street provides east-west access between the Felida and Salmon Creek areas in the northern portion of the Vancouver Urbanized area. According to the Clark County Comprehensive Plan, N.E. 134th Street is generally classified as a collector street between Tenny Road and Salmon Creek Avenue. A short section of N.E. 134th Street between Highway 99 and N.E. 20th Avenue is classified as a minor arterial.

Between N.E. Tenny Road and the northbound Interstate 5 off-ramp, N.E. 134th Street has two travel lanes in each direction on 24-feet of pavement. Both the I-5 off-ramp and the access road to the Salmon Creek Park-and-Ride lot are stop sign-controlled. The posted speed limit is 30 MPH. No on-street parking is allowed.

Between the northbound I-5 off-ramp and Highway 99, 134th Street has three eastbound travel lanes and one westbound travel lane. the intersection with Highway 99 is currently signalized with left turn phasing for north and south movements. The eastbound right turn lane is a free-right with 100 percent green time. The posted speed limit is 30 MPH and no on-street parking is allowed.

Between Highway 99 and N.E. 20th Avenue, N.E. 134th Avenue has one through lane in each direction with a westbound left turn lane at Highway 99 and an eastbound left turn lane at N.E. 20th Avenue. The intersection of N.E. 134th Street with N.E. 20th Avenue is controlled by a four-way stop sign. The posted speed limit is 30 MPH and no on-street parking is permitted.

East of N.E. 20th Avenue, N.E. 134th Avenue has a single travel lane in each direction with provision of turning vehicles at the interchange with I-205. The northbound off-ramp from I-205 at N.E. 134th Street is stop sign-controlled as is N.E. 134th Avenue at its intersection with Salmon Creek Avenue. The posted speed limit is 35 MPH and there is generally between 18 and 24-feet of pavement with little or no shoulders. N.E. 134th Street narrows and has several sharp turns between the northbound I-205 off-ramp and Salmon Creek Avenue.

Highway 99 is a north-south major arterial street connecting the Salmon Creek area with Hazel Dell and, via Main Street, with downtown Vancouver. South of N.E. 134th Street, this street has two travel lanes in each direction with left turn channelization. Highway 99 is signalized at its intersections with N.E. 134th and N.E. 129th Streets.

N.E. 20th Avenue is a north-south collector roadway which provides two travel lanes in each direction between N.E. 134th and N.E. 139th Streets and one travel lane in each direction north of N.E. 139th Street. Pavement width varies between 20 and 34-feet. N.E. 20th Avenue is controlled by a four-way stop sign at its intersection with N.E. 134th Street. Between N.E. 134th Street and N.E. 139th Street, N.E. 20th Avenue has a posted speed limit of 25 MPH. North of N.E. 139th Street, there is a posted speed limit of 40 MPH.

N.E. 29th Avenue is a north-south collector which abuts the western edge of the WSU campus. In this area, N.E. 29th Avenue is a two-lane roadway which has a posted speed limit of 35 MPH north of N.E. 139th Street and 25 MPH to the south. N.E. 29th Avenue is stop sign-controlled at its intersection with N.E. 134th Street. The southbound approach at this intersection descends sharply and has a very oblique angle which makes right turns difficult.

Salmon Creek Avenue is a minor collector which runs along the southeastern edge of the WSU campus. In the study area, Salmon Creek Avenue has one travel lane in each direction and is generally posted with a 40 MPH speed limit. Existing pavement width varies between 18 to 20-feet. Some sight distance problems may exist at the intersection with N.E. 134th Street and in the vicinity of the WSU campus entrance.

N.E. 139th Street is a local access street which runs east-west between N.E. 20th and N.E. 29th Avenues. This street currently has one travel lane in each direction and is stop sign-controlled at its intersections with N.E. 20 and N.E. 29th Avenues. N.E. 139th Street has a posted 35 MPH speed limit. Pavement width is approximately 22-feet.

N.E. 179th Street is an east-west major collector linking Interstate 5 with the Clark County Fairgrounds and the rural/low density residential area north of the WSU campus. This street has one travel lane in each direction with limited shoulders. N.E. 179th Street is traffic signal-controlled at its intersection with the northbound I-5 off-ramp and stop sign-controlled at N.E. 50th Avenue. Pavement width is generally 22-feet. N.E. 179th Street is generally posted for 40 MPH speeds. However, at a number of locations there is impaired sight distance and the posted speed drops to 30 MPH.

N.E. 50th Avenue is a north-south collector street abutting the eastern edge of the WSU campus. This street has one travel lane in each direction and is stop sign-controlled at its intersection with Salmon Creek Avenue. Posted speed on N.E. 50th Avenue is 40 MPH.

## EXISTING TRAFFIC VOLUMES AND LEVELS OF SERVICE

### Existing Daily and Peak Hourly Traffic Volumes

Existing daily traffic volumes in and near the study area were obtained from the Clark County Department of Public Services and are summarized in Figure 6. As shown in this figure, Salmon Creek Avenue currently carries 1,800 vehicles per day in the vicinity of the campus, while N.E. 29th Avenue carries over 2,200 and N.E. 50th Avenue carries 1,250. These volumes are typical of rural roads in low density portions of the County.

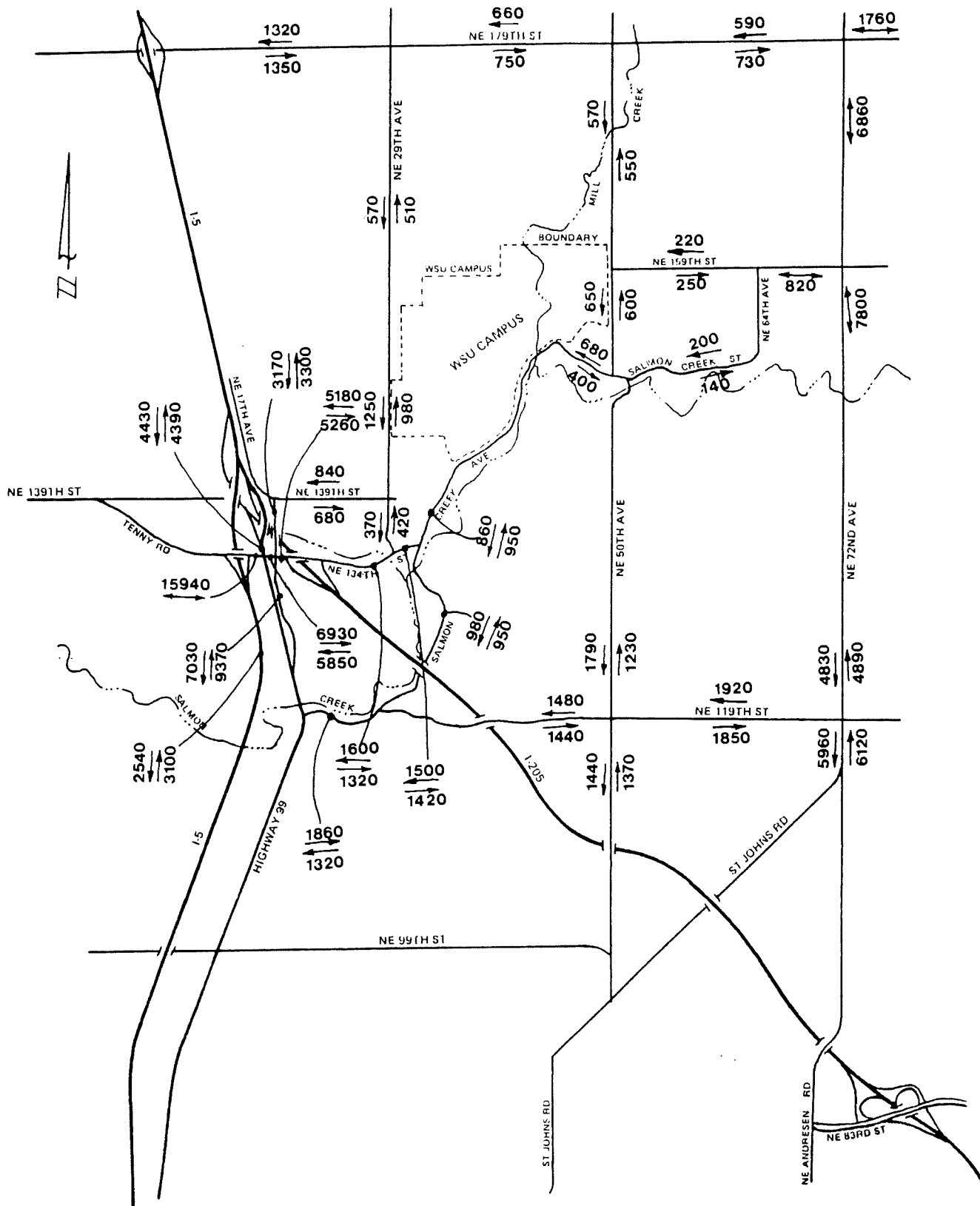
N.E. 134th Street currently carries nearly 16,000 daily vehicles between the northbound I-5 off-ramp and Highway 99. Between N.E. 20th Avenue and I-205, N.E. 134th Street carries approximately 10,500 daily vehicles. East of I-205, N.E. 134th Street carries nearly 3,000 vehicles per day.

As a part of this analysis, AM and PM peak hourly turning movement counts were conducted at key intersections in the study area. Included were eight intersections along N.E. 134th Street between the southbound I-5 on-ramp and Salmon Creek Avenue and three intersections at the I-5/N.E. 179th Street interchange. These counts were taken during October/November, 1991 and February, 1992 between 7 and 9 AM, and 4 and 6 PM. Turning movement counts are illustrated in Figure 7.

### Existing Level of Service Analysis

Based on the traffic volumes presented in Figure 7, and the intersection characteristics shown in Figure 5, peak hourly traffic operations were analyzed in the study area. This analysis was conducted using methodologies outlined in the 1985 Highway Capacity Manual (HCM).

According to the HCM, there are six levels of service (LOS) by which the operating performance of an intersection may be described. These levels of service range from LOS "A" which indicates a relatively free-flowing condition to LOS "F" which indicates operational breakdown. Level of service "D" has been identified by the County as the minimum acceptable standard. With this level of service, some delays are expected for certain traffic movements. Table 1 on the following page illustrates the traffic operating characteristics associated with each level of service.



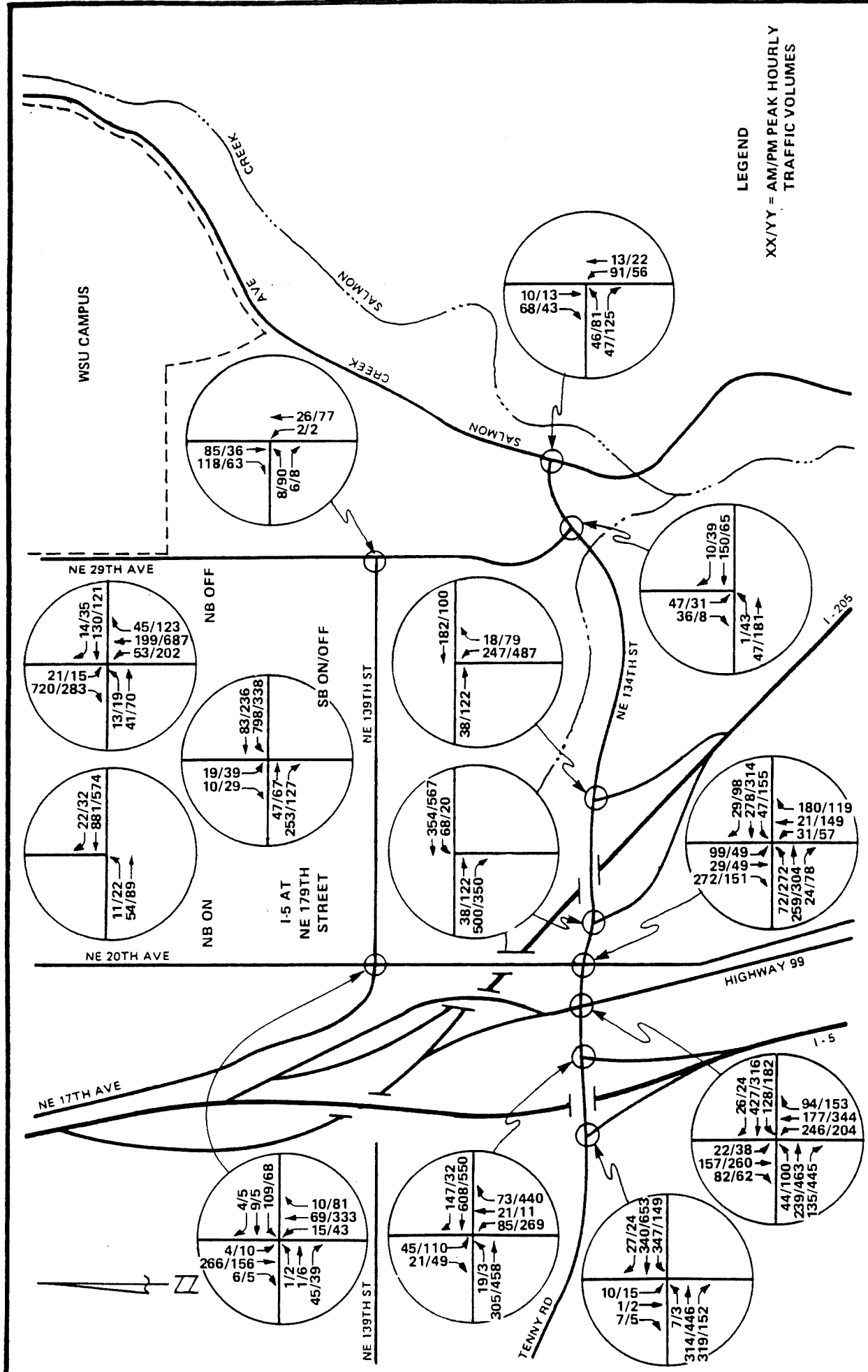
**Kimley-Horn**

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**FIGURE 6**

**EXISTING AVERAGE DAILY  
TRAFFIC VOLUMES**





### EXISTING PEAK HOUR TRAFFIC VOLUMES

**Kimley-Horn**

## FIGURE 7

Table 1  
 Characteristics of Various Traffic  
 Levels of Service

<u>Level of Service</u>	<u>Operating Characteristics</u>
A	Represents free flow      Individual users are virtually unaffected by the presence of others in the traffic stream.
B	In the range of stable flow but the presence of other users in the traffic stream begins to be noticeable.
C	Stable flow but marks the beginning of the range of flow in which the operation of individual users becomes significantly affected by interactions with others in the traffic stream.
D	Represents high-density but stable flow      Speed and freedom to maneuver are severely restricted and the driver generally experiences a poor level of comfort and convenience.
E	Represents operating conditions at or near the capacity level. All speeds are reduced to a low, but relatively uniform value. Freedom to maneuver within the traffic stream is extremely difficult, and it is generally accomplished by forcing a vehicle to "give way" to accommodate such maneuvers. Comfort and convenience levels are extremely poor and driver frustration is generally high.
F	This level of service is used to define forced or breakdown flow. This condition exists whenever the amount of traffic approaching a point exceeds the amount which can traverse the point. Queues form behind such locations. Operations within the queue are characterized by stop-and-go waves, and they are extremely unstable.

Figure 8 presents a summary of existing traffic operations at key intersections in the study area. As indicated in this figure, all intersections currently operate at an acceptable LOS "D" or better with three exceptions. The intersection of N.E. 179th Street with the southbound I-5 on/off ramps currently operates at LOS "F" during the AM peak hour, primarily because of the very large west-to-southbound left turning movement. While the intersections of N.E. 179th Street with the northbound on- and northbound off-ramps currently operate at LOS "A" and "B", respectively, delays to westbound traffic at the southbound ramps cause adverse impacts to these two intersections as a result of traffic queueing and reduced vehicular speeds under the freeway.

The intersection of N.E. 134th Street with the southbound I-5 on-ramp operates at LOS "E" during the AM peak hour, also because of a large west-to-southbound left turning movement. The intersection of N.E. 134th Street with the northbound I-5 off-ramp currently experiences LOS "F" during the AM peak hour and LOS "E" during the PM peak hour.

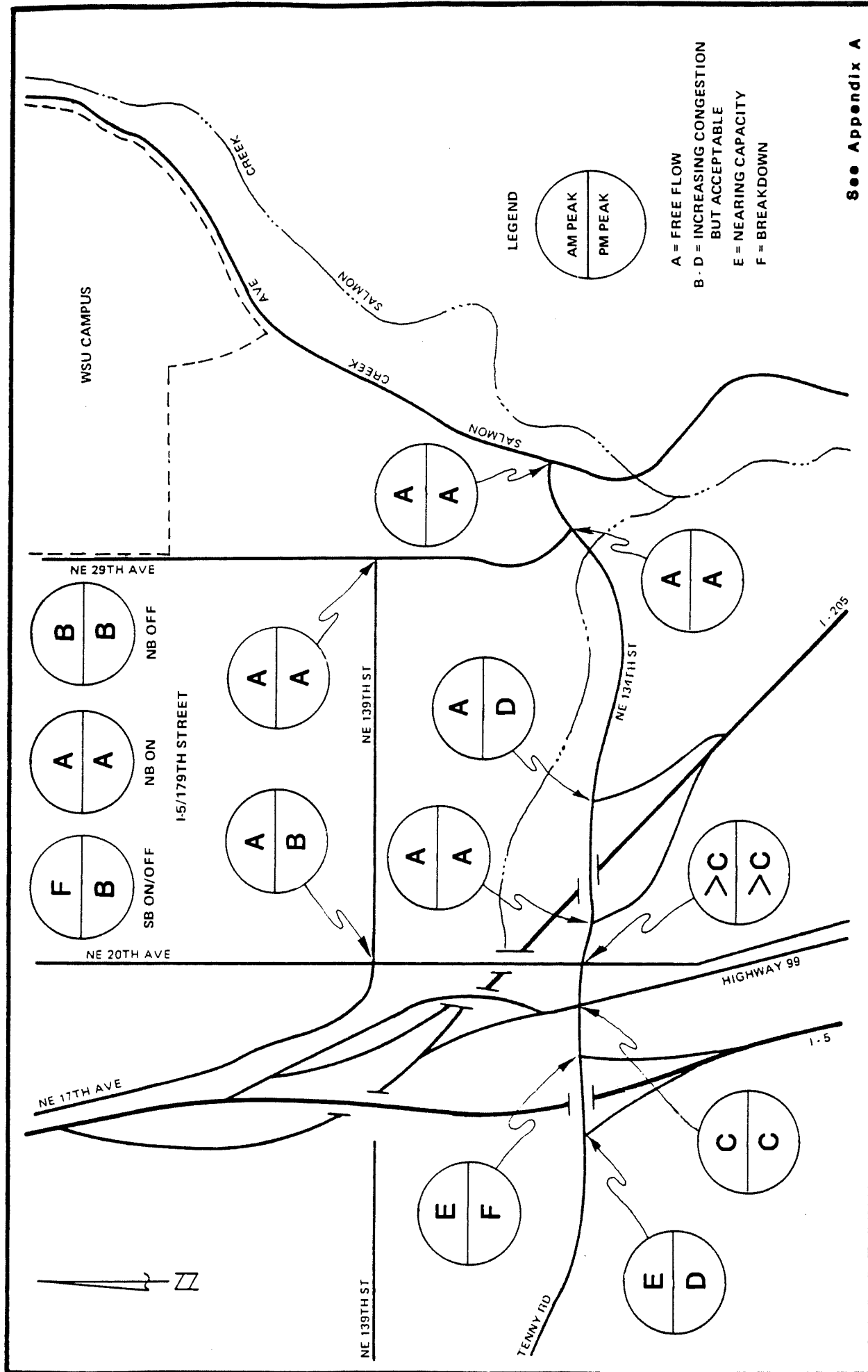
The signalized intersection of N.E. 134th Street at Highway 99 currently operates at an acceptable level of service during both the AM and PM peak hours. However, field observations indicate that during the PM peak 15-20 minutes, the traffic signal at the intersection of N.E. 134th Street with Highway 99 operates with a very long average signal cycle (approximately 120 seconds). This results in overall LOS "D" operations during this time period. Also during the peak 15 minutes, traffic queues were observed to back up into the adjacent intersections at the northbound I-5 off-ramp and N.E. 20th Avenue, constraining traffic operations at these intersections.

A summary of the level of service analysis for existing conditions is presented in Appendix A.

Mitigation of the traffic congestion problems identified above can be achieved by implementation of the proposed roadway improvements which will be described in the following section.

## ACCIDENT HISTORY

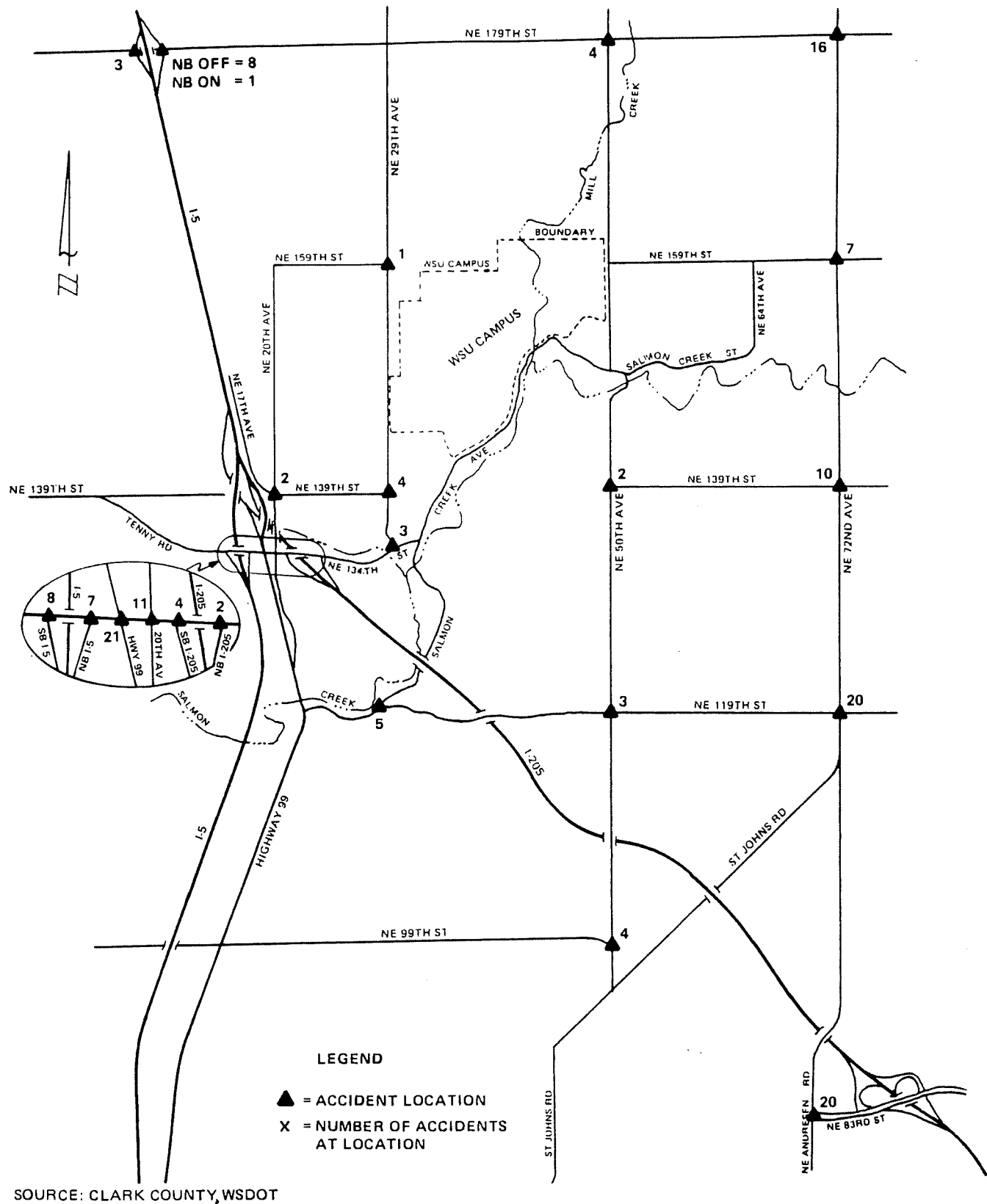
Figure 9 presents a summary of reported accidents during the period January 1, 1988 through December 31, 1991, at key intersections in the vicinity of the WSU campus. As indicated in this figure, N.E. 72nd Avenue has several intersections which have experienced a high number of accidents (10 or more during the past four years). Other locations which have experienced high numbers of accidents include the intersections of N.E. 134th Street with Highway 99 and N.E. 20th Avenue.



**FIGURE 8**

**EXISTING LEVELS OF SERVICE AT KEY INTERSECTIONS**

**Kimley-Horn**



**Kimley-Horn**

Kimley-Horn and Associates, Inc.

**FIGURE 9**

**REPORTED ACCIDENTS AT KEY INTERSECTIONS  
(1988-1991)**

Accident rates per million entering vehicles were calculated for intersections where reported accidents occurred and daily traffic volume data was available. The results of this analysis are depicted in Table 2.

Table 2

Accident Rates at Key Intersections in Vicinity of the  
Proposed WSU Campus

<u>Intersection</u>	<u>Number of Accidents</u>	<u>Accident Rate per Million Entering Vehicles</u>
N.E. 119th St. @ N.E. 72nd Ave.	20	2.01
N.E. 179th St. @ N.E. 72nd Ave.	16	1.61
N.E. 134th St. @ Hwy. 99	21	1.46
N.E. 139th St. @ N.E. 29th Ave.	4	1.38
N.E. 179th St. @ N.E. 50th Ave.	4	1.21
N.E. 119th St. @ Salmon Creek Av.	5	0.91
N.E. 134th St. @ N.E. 29th Ave.	3	0.78
N.E. 159th St. @ N.E. 72nd Ave.	7	0.69
N.E. 134th St. @ N.E. 20th Ave.	11	0.63
N.E. 119th St. @ N.E. 50th Ave.	3	0.37
N.E. 179th St. @ N.E. 29th Ave.	1	0.23

As indicated in Table 2, five of the intersections analyzed experienced over one accident per million entering vehicles. One accident per million entering vehicles is considered by Clark County as a general threshold whereby a high accident location may be identified. The highest accident rates in the vicinity of the project were experienced at the intersections of N.E. 119th Street at N.E. 72nd Avenue, N.E. 179th Street at N.E. 72nd Avenue and N.E. 134th Street at Highway 99. These intersections experienced accident rates of 1.71, 1.37 and 1.24 accidents per million entering vehicles, respectively.

#### EXISTING TRANSIT SERVICE

Existing transit service within the study area is provided by C-TRAN for the general public and by the Vancouver and Battle Ground School Districts for their students. These services are described in the following paragraphs.

## C-TRAN Public Transportation Services

As the public transportation provider in Clark County, C-TRAN is responsible for facilities and services designed to provide a major alternative to use of the private automobile. Currently, there is no C-TRAN service in the immediate vicinity of the WSU campus site as the area consists of low density residential and rural land uses and lacks a major trip attractor which would make transit service more viable. Existing bus routes are depicted in Figure 10 and are largely concentrated near the intersection of N.E. 134th Street and Highway 99. Included are routes 6, 8, 25, 73 and 134. These routes are described in the following paragraphs and illustrated in Figure 10.

The #6 Hazel Dell route travels on Highway 99 between the Salmon Creek Park-and-Ride lot and N.E. 119th Street and links this lot to the Hazel Dell area. Service is provided half hourly during the AM and PM peak periods and hourly during the remainder of the service day. Weekday service hours for this route are from 5:45 AM to approximately 10:00 PM. Service is also provided on Saturdays and Sundays.

The #8 Ridgefield/La Center route travels between the Salmon Creek Park-and-Ride lot and the Towns of Ridgefield and La Center. In the vicinity of the WSU campus, this route uses N.E. 134th Street, N.E. 20th Avenue, Union Avenue and N.E. 10th Avenue. Service is provided during peak weekday hours only beginning at 6:15 AM and ending at 6:47 PM.

Route # 25 serves the St. John's area and makes a one-way loop using primarily N.E. 50th Avenue, N.E. 109th Street, N.E. 119th Street N.E. 72nd Avenue and St. John's Road. Weekday service is provided every half hour during the AM and PM peak periods and hourly throughout the remainder of the day. Service begins at 6:03 AM and ends at 8:45 PM. Service is also provided on weekends.

The #71 Highway 99 route travels north-south on Highway 99 between the Salmon Creek Park-and-Ride lot and downtown Vancouver. This route provides half hourly service during peak periods and hourly service during the rest of the day. Weekday service hours for Route #71 are from 5:45 AM to 10:15 PM. Service is also provided on weekends.

Route #73, the Battle Ground Express operates on weekdays only between downtown Vancouver and the Battle Ground Park-and-Ride lot. Service is not provided to the Salmon Creek Park-and-Ride lot. One southbound trip is provided during the AM peak period and one northbound trip is provided during the PM peak period.





The route #134 Salmon Creek Express provides weekday peak period service only between the Salmon Creek Park-and-Ride lot and the downtown Portland transit mall. Service is provided on approximately 15 minute frequencies between the hours of 6:15 AM to 9:03 AM and 3:45 PM to 6:38 PM.

#### School Bus Service

Both the Vancouver and Battle Ground School Districts currently provide pupil transportation on many of the roads and streets in the vicinity of the WSU campus site. Figure 11 illustrates these routes and indicates the number of buses per day on each roadway segment. Most heavily utilized in the study area are N.E. 134th Street, N.E. 20th Avenue, N.E. 29th Avenue and Salmon Creek Avenue.



## SECTION III

### FUTURE CONDITIONS

#### PLANNED ROADWAY IMPROVEMENTS

Figure 12 presents the pending and/or proposed roadway improvements in the vicinity of the WSU campus. As indicated in this figure, improvements are scheduled for construction in 1993 along N.E. 134th Street between the southbound I-5 on-ramp and N.E. 20th Avenue. These improvements include:

- Reconstruction of the Interstate 5 interchange and widening of N.E. 134th Street to a five lane section between just west of the southbound ramp to I-5 and just east of N.E. 20th Avenue.
- Installation of a traffic signal at the intersection of N.E. 134th Street with N.E. 20th Avenue.

Other improvements have been proposed in the study area which have not been scheduled or funded to date. These proposed improvements include:

- Realigning and widening N.E. 134th Street between Rockwell Drive and Salmon Creek Avenue. This section of roadway will be widened to provide two-12 foot travel lanes and shoulders. Some improvements would also be made at the intersections with N.E. 29th Avenue and Salmon Creek Avenue. No additional lane capacity would be added.
- Improvement to the interchange of N.E. 179th Street at I-5 to accommodate an major expected increase in traffic activity associated with land development in this area. Long-range plans call for N.E. 179th Street to be widened to six lanes under I-5 and for various improvements to the ramp intersections. Interim improvements at this interchange have also been identified which include signalization of the intersection of N.E. 179th Street with the southbound ramps and addition of a second northbound through lane at the intersection of N.E. 179th Street with the northbound off-ramp. The timing of these improvements has not yet been determined.

In addition, the formation of an R.I.D. is presently under consideration to construct a new road along the alignment of N.E. 15th Avenue between N.E. 179th Street and the transition to N.E. 20th Avenue. Creation of this R.I.D. and the timing and funding for this improvement is uncertain.



## BACKGROUND TRAFFIC VOLUMES FOR 1998 AND 2010

Traffic volume projections were prepared for 1998 and 2010 to aid in the analysis of short- and long-term traffic impacts associated with development of the WSU campus site. Referred to as "background" traffic volumes, these projections do not include any traffic associated with development of WSU. However, the time periods selected are consistent with the scheduled Phase I and Phase II development of the campus. Background traffic volumes will be added to WSU traffic and used as the basis for conducting an evaluation of traffic impacts. The impacts attributable to development of the campus will be addressed in Section IV.

Future background traffic volumes for 1998 and 2010 were developed as follows:

1. Using modeled traffic estimates for 1990 and 2010 obtained from Clark County, the rate of growth expected between these two years was identified and applied to existing traffic counts. Where appropriate, modifications were made to the projections to ensure consistency in traffic flow from one adjacent intersection to the next. The numbers obtained from this analysis represented year 2010 background traffic projections.
2. 1998 projections were developed by interpolation between existing volumes and the 2010 projections. These volumes reflect a significant level of land development in the project area.

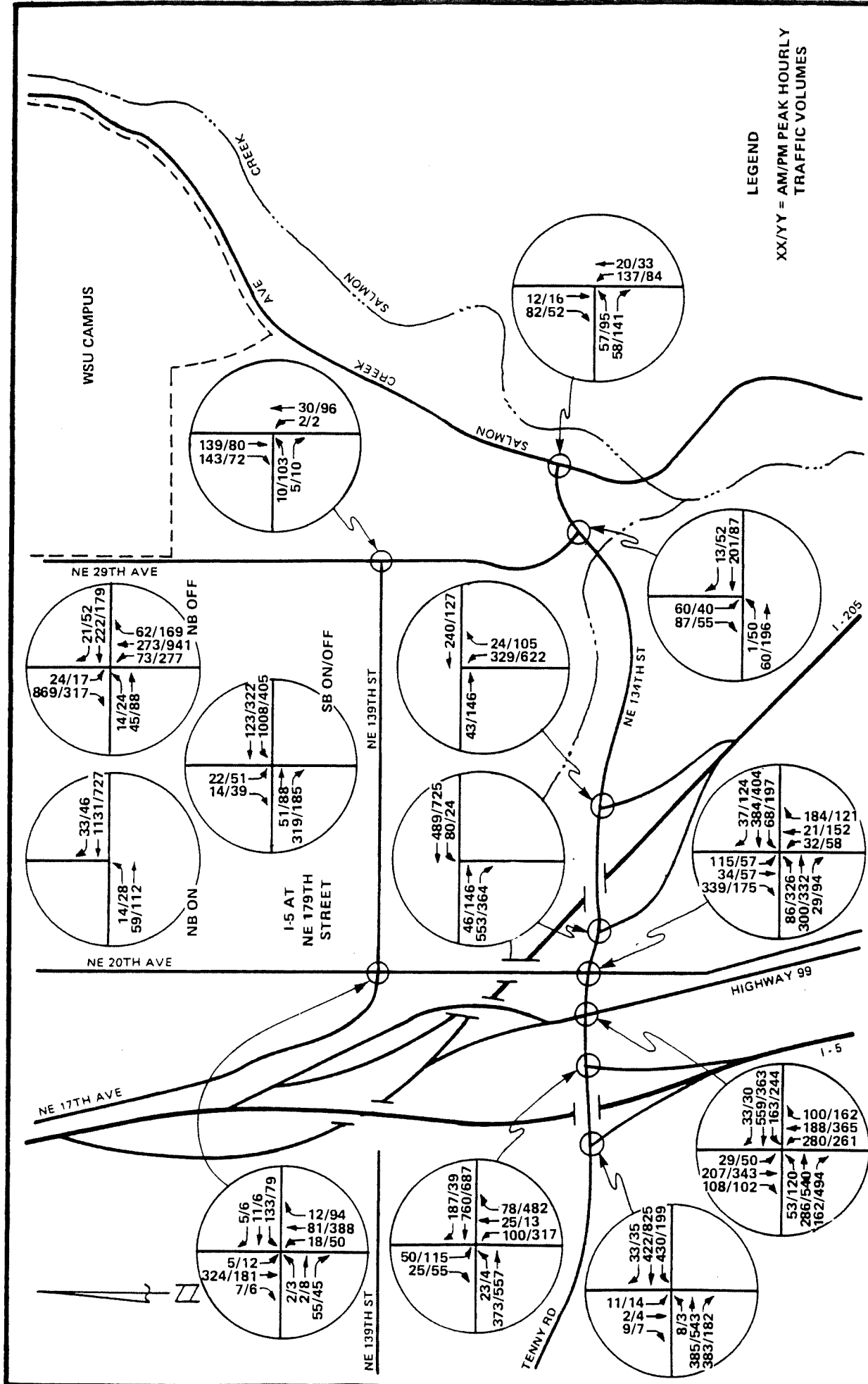
The rate of growth in traffic projections assumes considerable development in the project area consistent with the County's Comprehensive Plan. A summary of anticipated levels of growth in population, employment and travel demand is presented in Table 3. According to data received from the Intergovernmental Resource Center, by 2010, population growth is expected to occupy 57 percent of the currently available vacant land planned for single family development and 37 percent of the land available for multi-family development. Employment growth is expected to consume 27 percent of land available for commercial development and 25 percent of land available for industrial development.

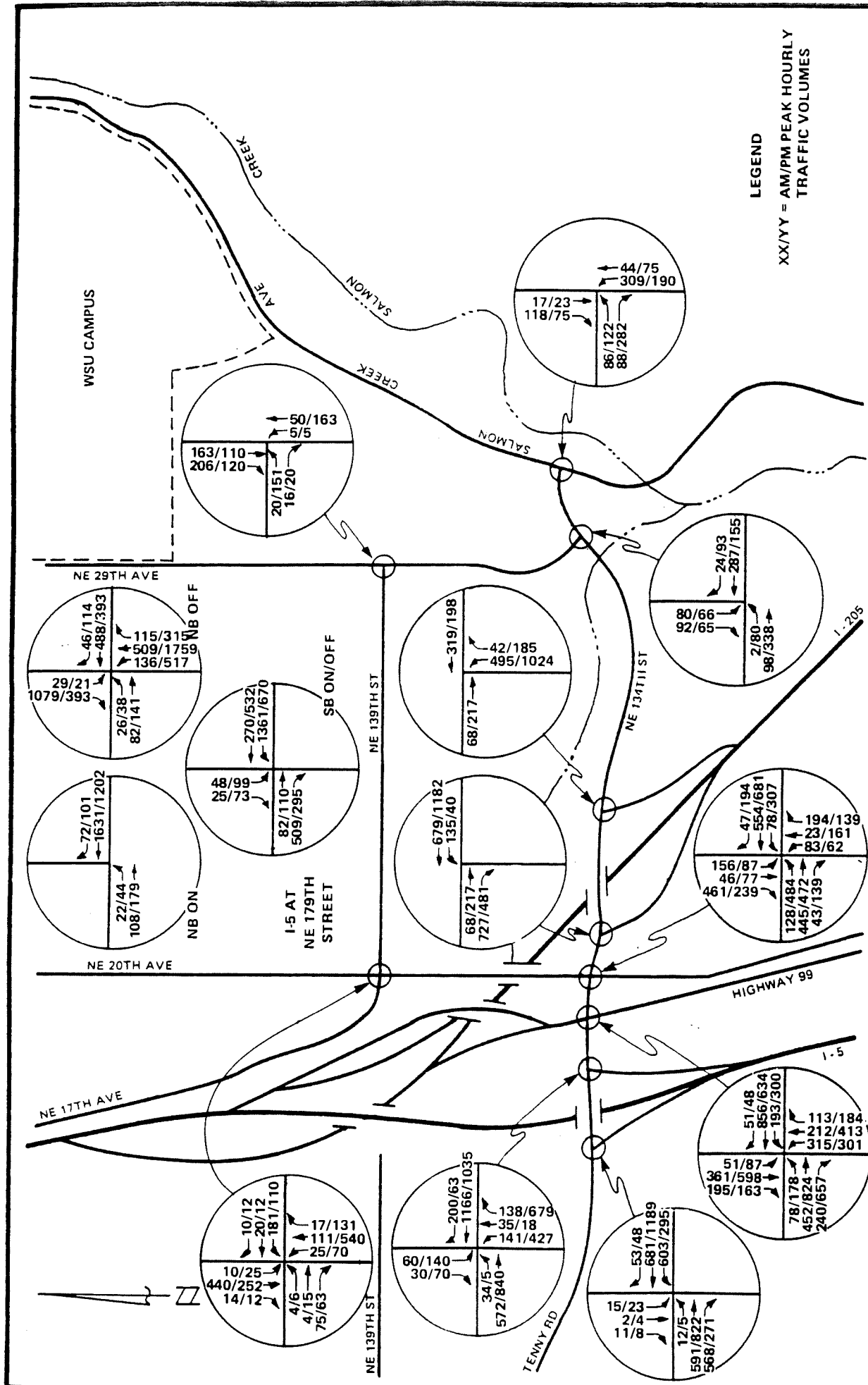
Estimates of peak hourly traffic volumes at key intersections in the study area are illustrated in Figure 13 for 1998 and in Figure 14 for 2010. Note that the background traffic volumes shown in these figures assume no development on the WSU site.

FIGURE 13

1998 PEAK HOUR TRAFFIC VOLUMES WITHOUT WSU

Kimley-Horn





2010 PEAK HOUR TRAFFIC VOLUMES WITHOUT WSU

Kimley-Horn

FIGURE 14

Table 3

Population, Employment and Travel Growth  
in WSU Study Area, 1988-2010

<u>Year</u>	<u>Households</u>	<u>Employment</u>	<u>Trip Ends</u>
1988	3,836	2,081	36,345
1998 - Number	5,725	3,021	49,366
% over 1988	+49%	+45%	+36%
2010 - Number	7,992	4,150	64,991
% over 1988	+108%	+99%	+79%
% over 1998	+40%	+37%	+32%

#### LEVEL OF SERVICE ANALYSIS FOR 1998 AND 2010

Based on the traffic volumes presented in Figures 13 and 14, future peak hourly traffic operations were analyzed in the study area. As with existing conditions, this analysis was conducted using methodologies outlined in the 1985 Highway Capacity Manual (HCM).

Intersection capacity analysis for 1998 assumes that the pending roadway improvements at the N.E. 134th Avenue and I-5 interchange area will be completed, as well as the proposed interim improvements to the interchange of N.E. 179th and I-5. These improvements are illustrated in Figure A-1 in Appendix A. The results of this analysis are graphically illustrated in Figure 15 and described in more detail in Appendix A.

According to Figure 15, with one exception, all intersections in the study area are expected to operate at an acceptable level of service "D" or better with the pending/proposed roadway improvements previously described. The intersection of N.E. 134th Street with the northbound I-205 off-ramp is expected to experience LOS "F" conditions for northbound left turns during the PM peak hour. This condition could be mitigated by installation of a traffic signal at this location. However, traffic signal warrants are not expected to be met.

Intersection capacity analysis for 2010 presupposes the improvements expected to be in place by 1998. In addition, this analysis also assumes that some degree of additional long-term improvements will be constructed at the N.E. 179th/I-5 interchange. These additional improvements are illustrated in Figure A-2 in Appendix A. The results of this analysis are also illustrated in Figure 15 and described in more detail in Appendix A.

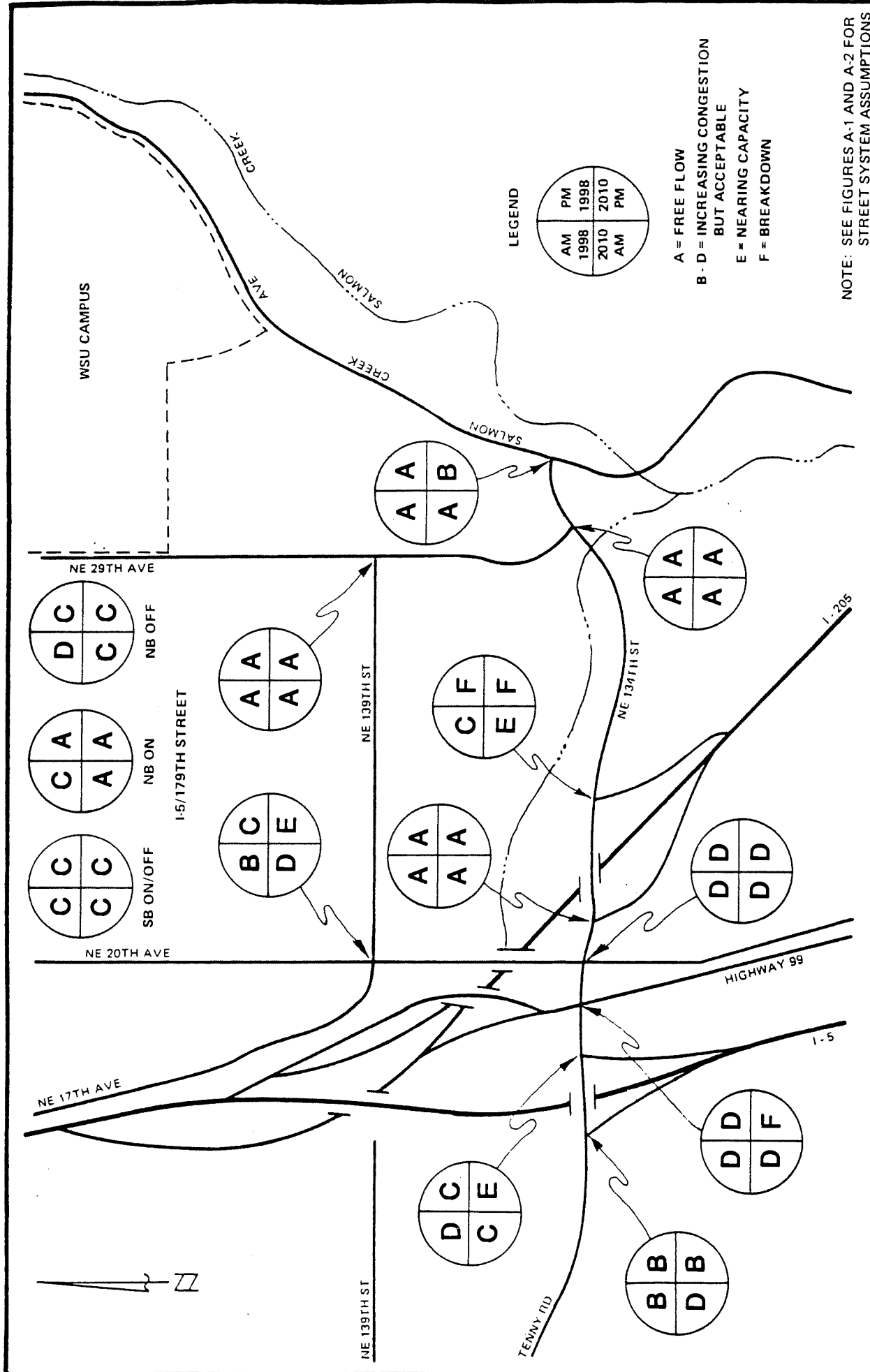


**FIGURE 15**

**FUTURE LEVELS OF SERVICE AT KEY INTERSECTIONS**

**Kimley-Horn**

NOTE: SEE FIGURES A-1 AND A-2 FOR STREET SYSTEM ASSUMPTIONS



According to Figure 15, three intersections are expected to operate at less than level of service "D" during the AM and/or PM peak hours. These intersections include:

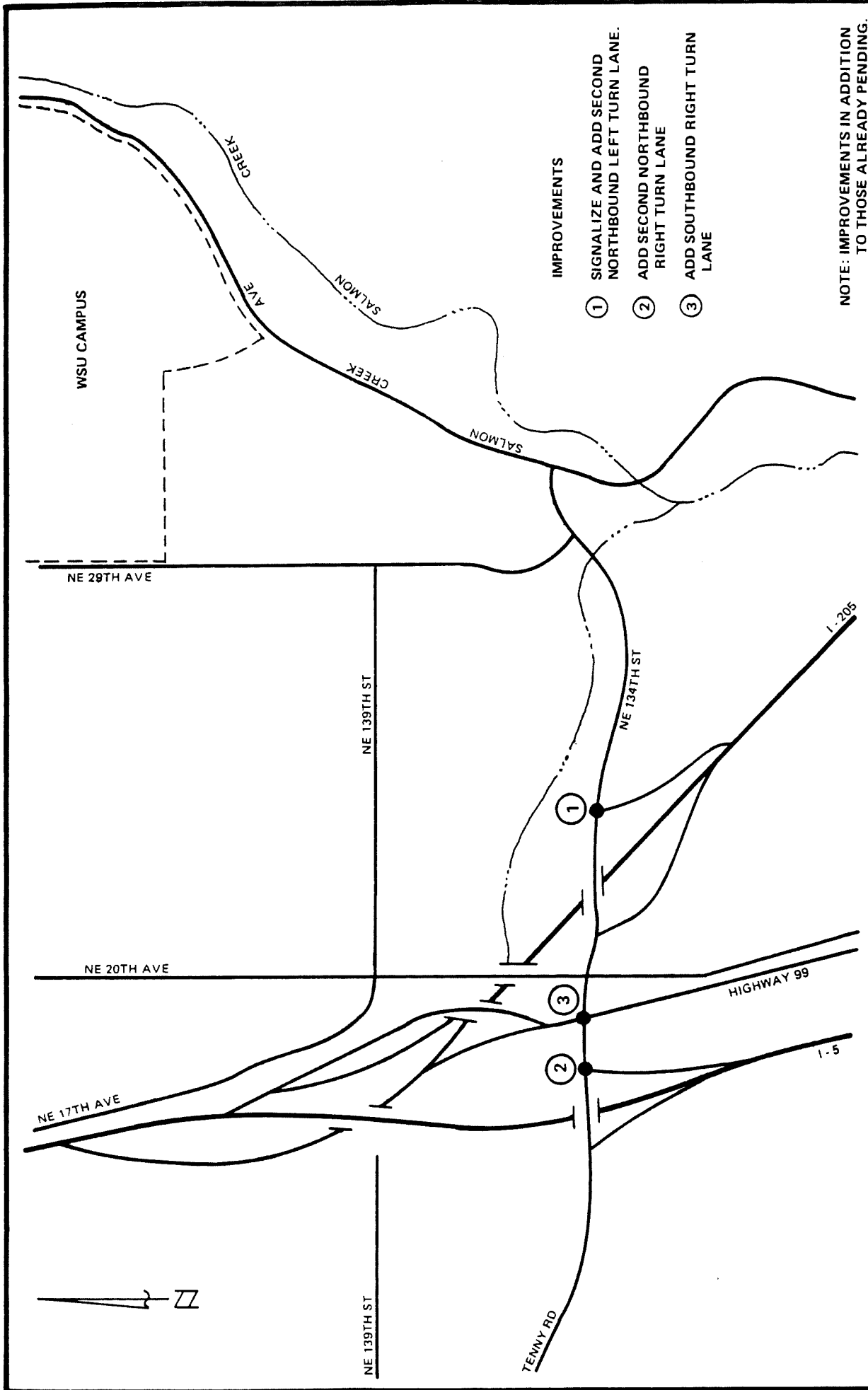
- N.E. 134th Street at the northbound I-5 off-ramp which is expected to operate at LOS "D" during the AM peak hour and LOS "E" during the PM peak hour.
- N.E. 134th Street at Highway 99 which is expected to operate at LOS "D" during the AM peak hour and LOS "F" during the PM peak hour.
- N.E. 134th Street at the northbound I-205 off-ramp which is expected to experience LOS "E" conditions for certain turning movements during the AM peak hour and LOS "F" for certain turning movements during the PM peak hour.

#### **ROADWAY IMPROVEMENTS NECESSARY TO ACCOMMODATE FUTURE BACKGROUND TRAFFIC VOLUMES**

Mitigation of the adverse traffic impacts identified above for 2010 will require a number of specific improvements. These improvements are depicted in Figure 16 and include:

- Signalize and add a second northbound left turn lane at the intersection of N.E. 134th Street with the northbound I-205 off-ramp. Level of service at this intersection after signal installation will be "B" during both the AM and PM peak hours.
- Addition of a second northbound right turn lane on the I-5 off-ramp where it intersects N.E. 134th Street. This will improve AM and PM peak hour levels of service to "D".
- Addition of a southbound right turn lane at the intersection of N.E. 134th Street with Highway 99. Levels of service will improve to "D" during both the AM and PM peak hours.

The results of intersection capacity analysis for the foregoing mitigation measures are documented more fully in Appendix B.



**NECESSARY ROADWAY IMPROVEMENTS BY 2010  
WITH BACKGROUND TRAFFIC ONLY**

**Kimley-Horn**

**FIGURE 16**

## SECTION IV

### TRAFFIC-RELATED IMPACTS OF WSU CAMPUS

#### ANALYSIS METHODOLOGY

Traffic-related impacts attributable to development of the Washington State University Salmon Creek campus are presented and discussed in this section. The analysis of traffic impacts addresses the three phases of development proposed for the WSU campus (with emphasis on Phases I and II), as well as a wide range of campus access alternatives. The analysis process includes the following steps:

- Estimation of the daily and peak hourly traffic generated by each phase of the proposed project. This estimation includes both traffic generated by students, faculty, staff and visitors to the University, and traffic generated by other activity on the site, related, but not specifically connected to the University;
- Distribution of this traffic to the surrounding street system. This distribution takes into account logical routes to/from the access location(s) which was identified in each access alternative. Trip distribution assumptions were developed for both Phase I and Phase II of campus development. Assumptions were also developed for the associated, non-University activities on the site;
- Evaluation of project-related traffic impacts at the key intersections in the study area for each development phase and each access alternative.
- Identification of necessary roadway and intersection improvements to mitigate the potential traffic impacts of each alternative.

The methodology, assumptions and results of each of the foregoing steps are discussed in the following sub-sections.

#### TRIP GENERATION BY PHASE

Trip generation analysis was conducted separately for the campus itself and for other associated land uses which may locate on the campus. These other land uses include: the United States Geological Survey (USGS) Cascades Volcano Observatory, a Contract Research Center and an Agricultural Research Unit Laboratory. Trip generation estimates for these separate land uses are discussed in the following paragraphs.

### Trip Generation for WSU Campus

The WSU Salmon Creek campus will be unique in the State of Washington and unusual in comparison with most other University campuses in the United States in that it will offer only upper division and graduate level courses. Lower division courses will be provided by the community colleges in Southwest Washington. WSU will also be a commuter-oriented campus. There will be no on-site residences nor will there be any large sports or special events facilities.

Because of the unique nature of the campus, the university does not readily fall into one of the trip generation categories commonly used for analysis of traffic impacts for this type of land use. According to the Institute of Transportation Engineers' (ITE) publication entitled "Trip Generation" (currently in its 5th edition), two categories of university development have been identified for which data on trip-making characteristics has been collected. These include four-year colleges and universities and two-year junior colleges. No category exists for two-year upper division/graduate universities.

In an attempt to develop the best estimate of trip-making characteristics likely to be experienced at the WSU campus, a more thorough literature review was conducted and consultation was initiated with the Metropolitan Service District (Metro) to identify an appropriate generation rate. Metro is the transportation planning agency for the Portland Metropolitan area and is responsible for regional transportation demand modeling within this area. This literature review and consultation revealed the following:

1. Within the past few years, Metro has updated its transportation model to specifically account for the travel demand characteristics associated with the nine universities and colleges located in its area of jurisdiction. Review of Metro's assumptions indicated that rates very comparable to those published in the ITE "Trip Generation, 4th Edition" publication are used as the basis for estimating trip generation. The rates used were 1.5 per student for junior colleges and 2.5 per student for universities. Trip generation estimates based on these rates were then reduced to eliminate trips made by employees so that these were not double counted. Employee trip-making was estimated and accounted for separately in the travel demand model.
2. The Junior/Community College rates published in the 4th Edition of ITE's "Trip Generation" were reviewed. These rates include both two- and four-year institutions calling themselves junior college, community college or college. No distinction is made in this data between the number of academic years offered at the campus, nor was a distinction

made between residential and non-residential campuses. The distinction between trip-making on two- and four-year campuses is noted as desirable to provide more accurate trip generation estimates. The ITE 4th Edition Junior College rate is 1.55 trip ends per day per student.

The ITE 4th Edition rates for a University are based on a very small data sample and include both two- and four-year institutions which called themselves "University". The trip generation rate for this land use is 2.41 trip ends per day per student.

3. Trip generation rates published by the San Diego Association of Governments (SANDAG) for two-year junior colleges and four-year universities were also reviewed. These rates are 1.6 trip ends per day per student for junior colleges and 2.5 trip ends per day per student for universities. These rates were derived from studies conducted during the 1970's in the San Diego region.
4. The original EIS prepared during the site selection process for the WSU Salmon Creek campus relied on trip generation rates published in the National Cooperation Highway Research Program (NCHRP) report entitled "Quick-Response Urban Travel Estimation Techniques for Transferable Parameters, User's Guide", 1978. The trip generation rates identified in this report are the same as those used by Metro.
5. In the 5th Edition (1991) of the ITE publication "Trip Generation", a separation has been made between the trip-making characteristics of two- and four-year colleges and universities. The trip rate for a two-year Junior College was estimated to be 1.33 trip ends per day per student. The rate for a four-year University was estimated to be 2.37 trip ends per day per student.

As noted previously, the new WSU campus will provide a two-year program with upper division and graduate classes only. Additionally, there will be no on-campus residential development. These characteristics make the campus more similar to two-year non-residential junior colleges than to four-year residential universities. Accordingly, the decision was made to use trip generation rates for junior colleges to estimate likely vehicular travel to/from the WSU campus. Review of the foregoing literature search indicated that the most appropriate rates would be those published in the 5th Edition of "Trip Generation" (ITE code 540).

The level of transit ridership associated with the ITE rates is not specifically identified. Transit ridership to college/university campuses is dependent on the location of the campus within an urban area and on the level of transit service provided. The studies cited in the ITE publication were conducted

during the 1970 s for campuses in Delaware and Kansas with enrollments ranging from 2,350 to 5,900. It is assumed that transit trip-making at these institutions was low. Thus, the rates used for WSU may also reflect a low level of transit trip-making. The EIS originally prepared for the WSU Salmon Creek site further substantiates this assumption by noting that the current share of trip-making by transit to/from the temporary WSU campus located at Clark College is 6 percent. As this campus is located near the heart of the urban area and has relatively good transit service, it is expected that transit trip-making to the new site will be less. Assuming that a minimum level of transit service is provided to the campus, the 2 percent share of campus trips made by transit indicated in the original EIS appears to be reasonable. For purposes of this study, it is assumed that a minimum transit service will be provided to this site and that this level of transit ridership would be experienced.

Should a significantly higher level of transit service be provided and/or a major effort undertaken to make transit and other alternative travel modes more attractive, it can be expected that the share of campus-related trips made by transit will go up. This will be discussed more fully in Section V.

#### Trip Generation for Associated Land Uses on Campus

The U.S. Geological Survey and Contract Research buildings are expected to include both offices and research facilities/laboratories, while the Agriculture Station will include only a laboratory. For these land uses, the ITE rates for general office (ITE Code 710) and research center (ITE Code 760) were used to estimate trip-making characteristics. These land uses are expected to be developed shortly after completion and occupancy of Phase I on the campus. For purposes of this study, they are assumed to be in place with Phase I.

#### Trip Generation Summary

Table 4 presents a summary of WSU trip generation for project Phases I, II and III. As indicated in this table, Phase I of campus development is expected to attract approximately 2,400 students and to generate approximately 4,330 trip ends on a daily basis. This total includes trips associated with the non-WSU land uses on the campus. Of this total, almost 550 trip ends are expected during the AM peak hour and about 490 trip ends are expected during the PM peak hour.

Upon completion of Phase II, WSU will have approximately 4,300 students and is expected to generate about 6,860 daily vehicle trip ends including non-WSU uses on the site. Of this total, approximately 850 trip ends are expected during the AM peak hour and nearly 760 trip ends are expected during the PM peak hour.

Table 4  
Summary of WSU Trip Generation

<u>Land Use</u>	<u>Size</u>	<u>Daily</u>	<u>Trip Ends</u>			
			<u>AM Peak</u>		<u>PM Peak</u>	
			<u>In</u>	<u>Out</u>	<u>In</u>	<u>Out</u>
<b>Phase I:</b>						
Campus	2,414 stdnts.	3,211	375	12	253	84
USGS						
Office	20 ksf	416	49	6	10	47
Research	40 ksf	308	41	8	6	36
Contract Research						
Office	8 ksf	208	24	3	5	24
Research	17 ksf	131	17	4	3	15
Ag. Station	7.8 ksf	60	8	2	1	7
		-----	---	--	---	---
Sub-Total (non-WSU)		1,123	139	23	25	129
Total Phase I		4,334	514	35	278	213
<b>Phase II:</b>						
Campus	4,310 stdnts.	5,732	669	21	453	151
USGS						
Office	20 ksf	416	49	6	10	47
Research	40 ksf	308	41	8	6	36
Contract Research						
Office	8 ksf	208	24	3	5	24
Research	17 ksf	131	17	4	3	15
Ag. Station	7.8 ksf	60	8	2	1	7
		-----	---	--	---	---
Sub-Total (non-WSU)		1,123	139	23	25	129
Total Phase II		6,855	808	44	478	280
<b>Phase III:</b>						
Campus	8,600 stdnts.	11,438	1,335	41	903	301
Office/Research	92.8 ksf	1,123	139	23	25	129
		-----	---	--	---	---
Total Phase III		6,855	808	44	478	280

Note: ksf means thousand of square feet.



## TRIP DISTRIBUTION

In order to determine the increase in traffic volumes at any given location resulting from project development, the generated trip ends must be distributed and assigned to the surrounding street system. For this report, trip distribution estimates were prepared for both Phase I and Phase II of campus development and for the non-WSU land uses on the campus.

Phase I (1998) trip distribution assumptions were developed by using the location of residence for existing students and faculty as a basis for determining the directional orientation of trips to/from the new campus. This information was provided by WSU at the zip code level. Figure C-1 in Appendix C shows the assumed distribution pattern for WSU campus trips in 1998.

Phase II (2010) trip distribution assumptions were based on the pattern established for 1998 which was modified to reflect increasing urbanization in the northern part of Clark County. With increased development activity north of the campus site, a higher percentage of students and/or faculty are expected to live in this area in 2010 than in 1998. The assumed distribution pattern for WSU campus trips in 2010 is shown in Figure C-2 of Appendix C.

Trip distribution assumptions for non-WSU office and research facilities were developed based on the relationship of the campus to major concentrations of residential and supportive office/commercial development throughout the remainder of the County. These assumptions are shown in Figure C-3 of Appendix C.

## DEVELOPMENT OF ACCESS ALTERNATIVES

As a part of this study, a wide range of campus access alternatives was evaluated to identify not only the traffic impacts associated with each, but also the necessary and appropriate mitigation measures which would be required with implementation. Each alternative was also evaluated in relation to proposed on-site campus development to identify ways in which the alternative was consistent with the overall master plan concept. Alternatives which were evaluated included those which took access at the following locations.

- Salmon Creek Avenue at approximately N.E. 35th Avenue
- N.E. 29th Avenue south of N.E. 150th Street
- N.E. 179th Street at approximately N.E. 40th Avenue
- Both Salmon Creek and N.E. 29th Avenues
- N.E. 50th Avenue at N.E. 159th Street
- N.E. 29th Avenue to/from the south only
- Both Salmon Creek Avenue and N.E. 29th Avenue to/from south only

Project-related traffic was distributed to the surrounding street system for each access alternative according to the trip distribution assumptions depicted in Appendix C. These traffic volumes were then added to the estimated background traffic for 1998 and 2010, as documented in Section III, and intersection capacity analysis was conducted.

The results of this analysis for each access alternative are summarized in Table 5 for 1998 and in Table 6 for 2010. In these tables, a level of service value has been identified for the key intersections affected by each access alternative. According to Clark County policy, level of service "D" is the minimum acceptable standard for intersection operations. With this level of service, some delays are expected for certain traffic movements. Levels of service "E" or "F" indicate that intersection and/or signalization improvements may be necessary.

The characteristics and traffic-related impacts of each access alternative are discussed more fully in the following subsections. It should be noted that for the analysis of 1998 project-related traffic impacts, the roadway improvements discussed in Section III and documented in Figure A-1 of Appendix A are assumed to be in place. For 2010, the improvements documented in Figure A-2 are assumed to be in place.

#### **ANALYSIS OF SALMON CREEK AVENUE ACCESS**

Access to the campus site from Salmon Creek Avenue would be taken at approximately N.E. 35th Avenue or at a point to the east. The major route to this access point would be along Salmon Creek Avenue to N.E. 134th Street and then to I-205, I-5, Highway 99 or another local street. Access would also be available to the east along Salmon Creek Avenue. 1998 and 2010 traffic projections including WSU traffic to/from this access location are presented in Appendix D, as are tables which summarize the intersection capacity analysis.

Figure 17 shows future levels of service (LOS) at key intersections in the study area with the Salmon Creek Avenue access alternative. In 1998, this alternative will not adversely impact most of the intersections in the study area. Exceptions include the intersection of N.E. 134th Street with Salmon Creek Avenue (which would operate at LOS "E" for eastbound traffic during the AM peak hour) and the intersection of N.E. 134th Street with the northbound I-205 off-ramp (which would experience LOS "F" for northbound left turns during the PM peak hour).

Table 5

1998 Peak Hour Levels of Service  
for WSU Access Alternatives

Intersection	Alternative											
	Salmon Creek		29th Avenue		179th Avenue		29th Ave./ Salmon Ck.		50th Avenue		29th Ave. So. Only	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
134th Street at:												
I-5 SB on ramp	C	B	C	B	C	B	C	B	C	B	C	B
I-5 NB off ramp	C	C	C	C	C	C	C	C	C	C	C	C
Highway 99	D	D	D	D	D	D	D	D	D	D	D	D
20th Avenue	D	D	D	D	D	D	D	D	D	D	D	D
I-205 SB on ramp	A	A	A	A	A	A	A	A	A	A	A	A
I-205 NB off ramp	D	F	C	F	C	F	C	F	D	F	C	F
29th Avenue	B	B	A	A	A	A	A	A	B	B	A	A
Salmon Creek Avenue	E	D	A	A	A	A	B	A	E	C	A	A
179th Street at:												
I-5 SB ramps	C	C	C	C	C	C	C	C	C	C	C	C
I-5 NB on ramp	C	A	C	A	C	B	C	A	C	A	C	A
I-5 NB off ramp	D	C	D	C	D	C	D	C	D	C	D	C
139th Street at:												
20th Avenue	-	-	C	D	-	-	C	D	-	-	C	E
29th Avenue	-	-	C	C	-	-	B	B	-	-	D	B
WSU Access	C	B	B	B	A	A	A	A(1)	C	B	A	A
							A	A(2)			A	A

(1) N.E. 29th Avenue Access

(2) Salmon Creek Avenue Access

Note: At unsignalized intersections, LOS cited above refers to worst individual traffic movement.

Table 6

2010 Peak Hour Levels of Service  
for WSU Access Alternatives

Intersection	Alternative									
	Salmon Creek		29th Avenue		179th Avenue		29th Ave./ Salmon Ck.		50th Avenue	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
134th Street at:										
I-5 SB on ramp	D	B	D	B	D	B	D	B	D	B
I-5 NB off ramp	C	E	C	E	C	E	C	E	C	E
Highway 99	D	F	D	F	D	F	D	F	D	F
20th Avenue	D	D	D	D	D	D	D	D	D	D
I-205 SB on ramp	A	A	A	A	A	A	A	A	A	A
I-205 NB off ramp	F	F	E	F	E	F	E	F	E	F
29th Avenue	D	E	B	B	A	A	B	B	C	C
Salmon Creek Avenue	F	F	B	B	A	B	D	D	F	F
179th Street at:										
I-5 SB ramps	C	C	D	D	D	D	D	D	D	D
I-5 NB on ramp	A	A	A	A	A	A	A	A	A	A
I-5 NB off ramp	C	C	C	C	C	C	C	C	C	C
139th Street at:										
20th Avenue	-	-	D	F	-	-	E	F	-	-
29th Avenue	-	-	E	F	-	-	C	D	-	-
WSU Access	E	C	D	E	A	B	B	C(1)	C	D
							A	A(2)		
									B	D
									E	F
									F	F
									D	E
									A	B(1)
									A	A(2)

(1) N.E. 29th Avenue Access

(2) Salmon Creek Avenue Access

Note: At unsignalized intersections, LOS cited above refers to worst individual traffic movement.



By 2010, analysis indicates that LOS "E" or "F" conditions would be experienced during the AM peak hour at the intersections of N.E. 134th Street with the northbound I-205 off-ramp (for northbound left turns) and with Salmon Creek Avenue (for eastbound traffic). Eastbound left turns at the intersection of Salmon Creek Avenue with the WSU access road will also operate at LOS "E" during the AM peak hour. During the PM peak hour, LOS "E" or "F" would be experienced for the same traffic movements mentioned above at the intersections of N.E. 134th Street with the northbound I-205 off-ramp and Salmon Creek Avenue. Level of service "E" and "F" conditions would also be experienced at the intersections of N.E. 134th Street with the northbound I-5 off-ramp, Highway 99, and N.E. 29th Avenue (for southbound traffic).

#### ANALYSIS OF N.E. 29th AVENUE ACCESS

Access to the campus site from N.E. 29th Avenue would be taken at a point south of N.E. 150th Avenue and north of the southern end of the campus frontage on N.E. 29th Avenue. The major route to the access point would be along N.E. 29th Avenue to N.E. 139th Street, N.E. 20th Avenue and N.E. 134th Street. From N.E. 134th Street access is available to I-5 and I-205, as well as a number of local and arterial streets. Access would also be available to the north along N.E. 29th Avenue. 1998 and 2010 traffic projections including WSU traffic to/from this access location are presented in Appendix F, as are tables which summarize the intersection capacity analysis.

Figure 18 shows future levels of service at key intersections in the study area with the N.E. 29th Avenue access alternative. In 1998, this access alternative will not adversely impact most of the key intersections in the study area. The exception would be the intersection of N.E. 134th Street with the northbound I-205 off-ramp which would experience LOS "F" for northbound left turns during the PM peak hour.

By 2010, analysis indicates that LOS "E" conditions would be experienced at the intersection of N.E. 134th Street with the northbound I-205 off-ramp (for northbound left turns), and at the intersections of N.E. 139th Street with N.E. 29th Avenue (for eastbound traffic). During the PM peak hour LOS "F" would be experienced for the same traffic movements mentioned above at the intersection of N.E. 134th Street with the northbound I-205 off-ramp, and at the intersections of N.E. 139th Street with N.E. 29th Avenue. Additionally, LOS "E" or "F" conditions would be experienced at the intersections of N.E. 134th Street with the northbound I-5 off-ramp and Highway 99, at the intersection of N.E. 139th Street with N.E. 20th Avenue, and at the project access location on N.E. 29th Avenue (for westbound left turns).



## ANALYSIS OF N.E. 179th STREET ACCESS

Access to the campus site from N.E. 179th Street would be taken at a point located at approximately N.E. 40th Avenue. Use of this access point would require construction of a north-south road between N.E. 179th Street and the campus boundary, a distance of approximately 0.9 miles. The major route to this access point would be along N.E. 179th Street both to the west and east. Access to Interstate 5 is located to the west. 1998 and 2010 traffic projections including WSU traffic to/from this access location are presented in Appendix H, as are tables which summarize the intersection capacity analysis.

Future levels of service at key intersections in the study area with the N.E. 179th Street access alternative are depicted in Figure 19. Only one intersection is expected to experience adverse traffic impacts in 1998. Northbound left turns at the intersection of N.E. 134th Street with the northbound I-205 off-ramp are expected to operate at LOS "F" during the PM peak hour. However, these impacts are due almost solely to growth in background traffic and are not primarily attributable to WSU. All other intersections will operate at LOS "D" or better during both the AM and PM peak hours.

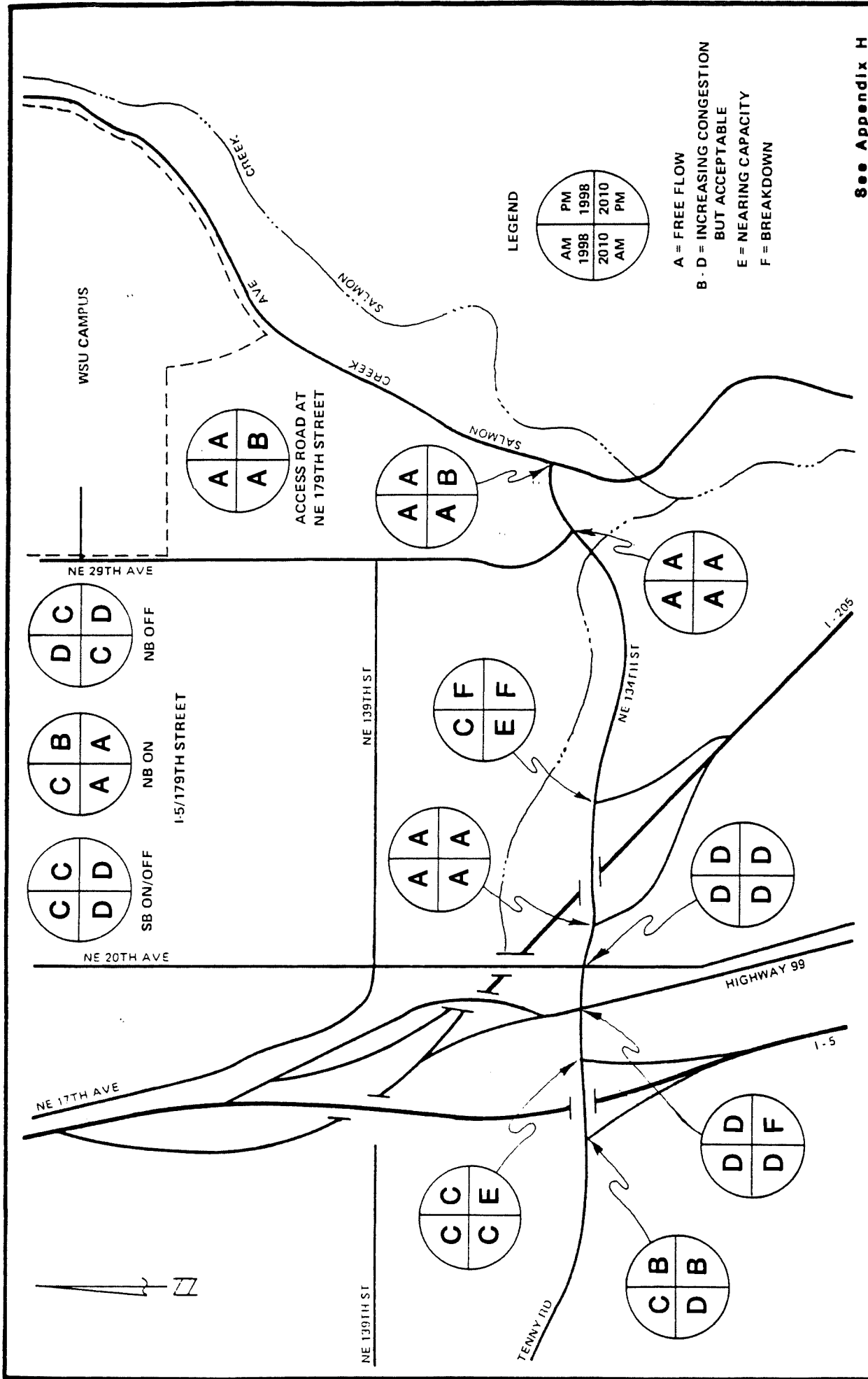
By 2010, analysis indicates that LOS "E" conditions would be experienced during the AM peak hour for northbound left turns at the intersection of N.E. 134th Street the northbound I-205 off-ramp. During the PM peak hour LOS "E" or "F" conditions would be experienced at the intersections of N.E. 134th Street with the northbound I-5 off-ramp, Highway 99 and the northbound I-205 off-ramp. All other major intersections in the study area are expected to operate at an acceptable level of service "D" or better during both the AM and PM peak hours.

## ANALYSIS OF ACCESS VIA BOTH SALMON CREEK AND N.E. 29th AVENUE

In this alternative, access to the WSU campus could be taken from both Salmon Creek and N.E. 29th Avenues at the general locations previously indicated. The major routes to these access points would use N.E. 134th Street, Salmon Creek Avenue, N.E. 20th and 29th Avenues and N.E. 139th Street. 1998 and 2010 traffic projections including WSU traffic to/from this access location are presented in Appendix J, as are tables which summarize the intersection capacity analysis.

Figure 20 presents future levels of service at key intersections in the study area with access available from both Salmon Creek Avenue and N.E. 29th Avenue. In 1998, the intersection of N.E. 134th Street with the northbound I-205 off-ramp is expected to operate at LOS "F" during the PM peak hour. All other intersections will operate at LOS "D" or better during both the AM and PM peak hours.





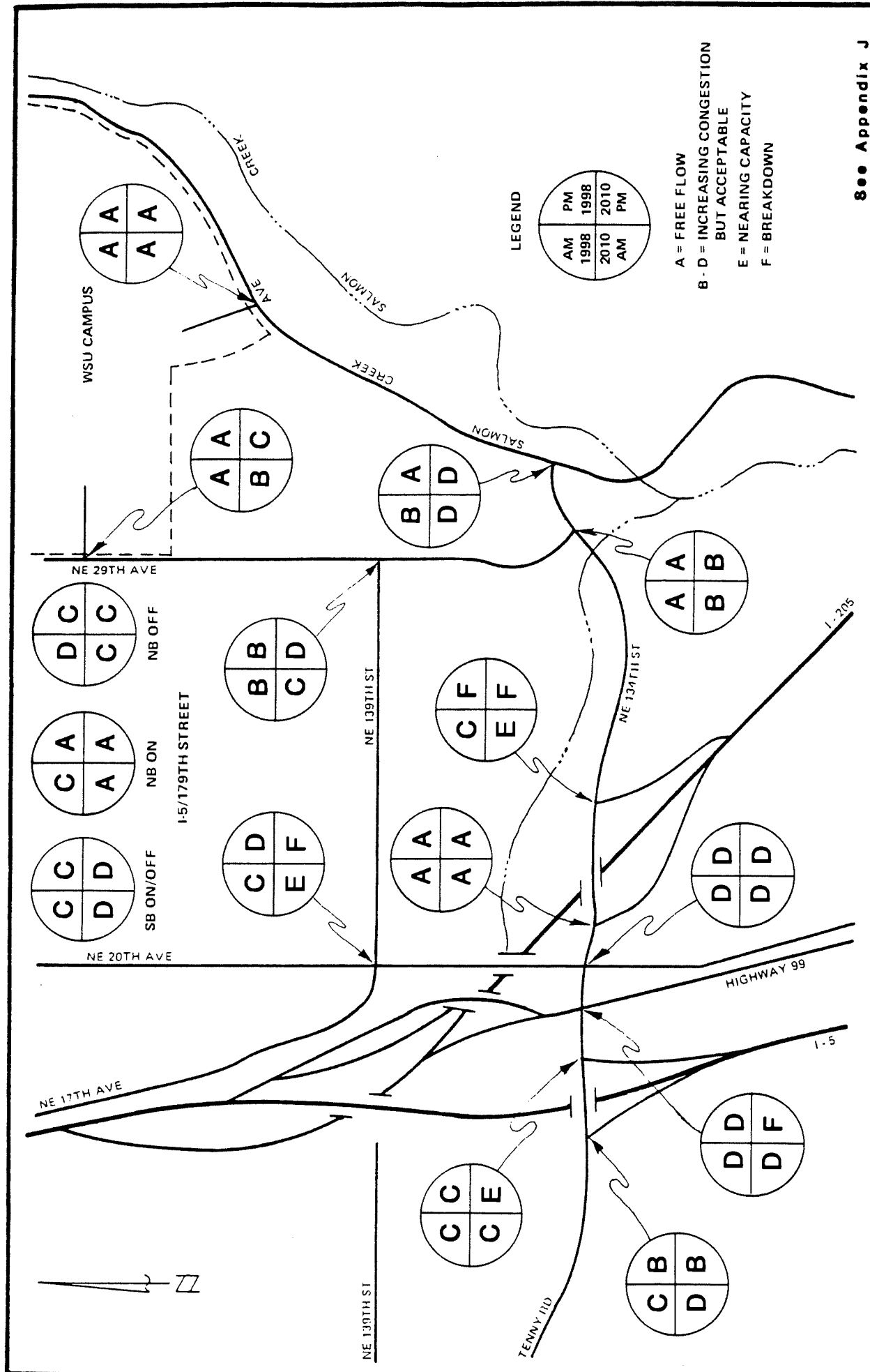
See Appendix H

# FUTURE LEVELS OF SERVICE AT KEY INTERSECTIONS WITH WSU

## N.E. 179TH STREET ACCESS

Kimley-Horn

FIGURE 19



See Appendix J

**FUTURE LEVELS OF SERVICE AT KEY INTERSECTIONS WITH WSU  
 SALMON CREEK AND N.E. 29TH AVENUE ACCESS**

**Kimley-Horn**

In 2010, two intersections in the study area are expected to experience levels of service "E" or "F" during both the AM and PM peak hours. These intersections are N.E. 134th Street at the northbound I-205 off-ramp (for northbound left turns) and N.E. 139th Street at N.E. 20th Avenue (for westbound traffic). During the PM peak hour, LOS "E" and "F" will also be experienced at the intersections of N.E. 134th Street with the northbound I-5 off-ramp and Highway 99.

#### ANALYSIS OF N.E. 50th AVENUE ACCESS

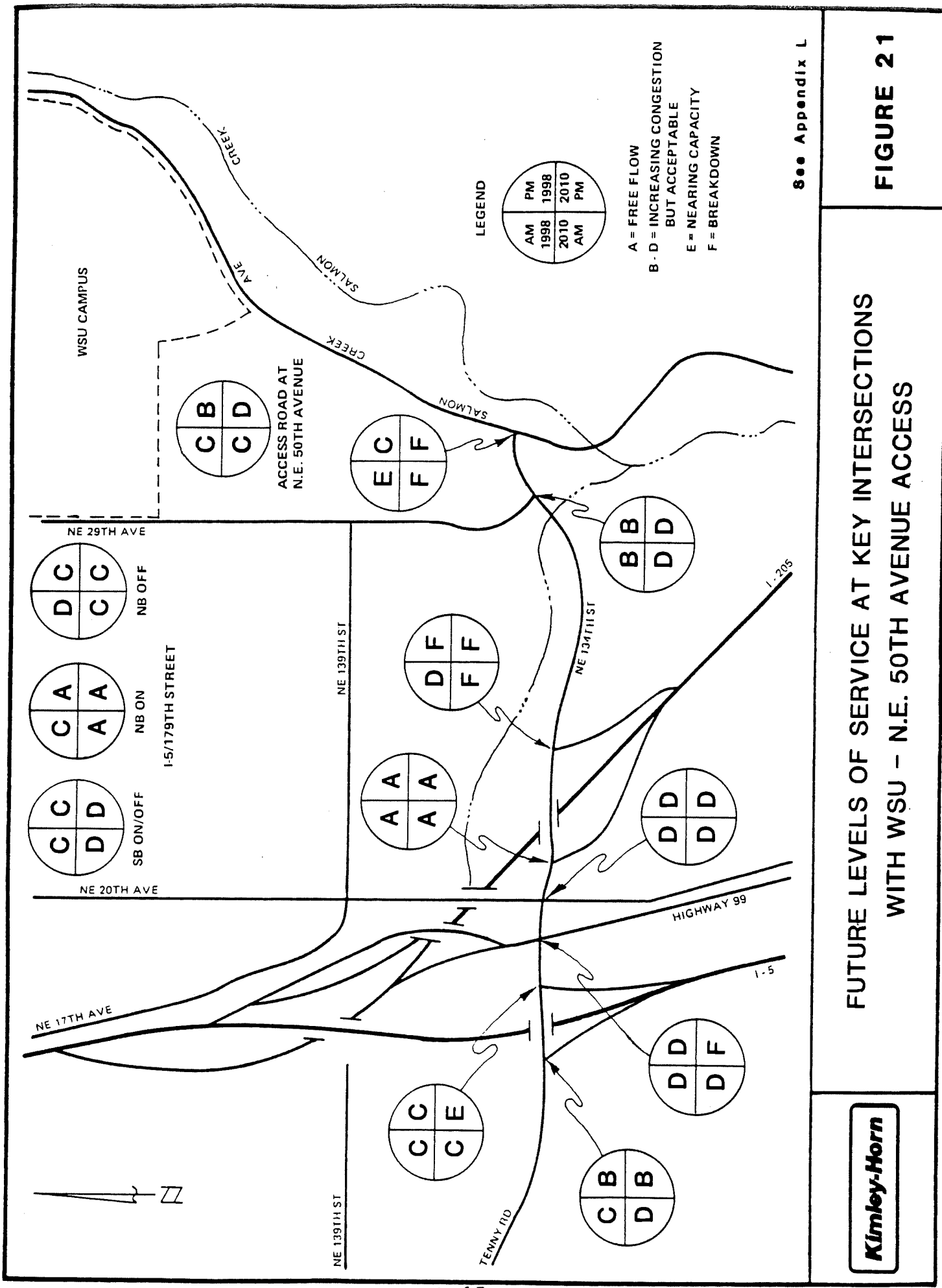
Access to the campus site from N.E. 50th Avenue would be taken at the existing intersection of the road with N.E. 159th Street. Use of this access point would require construction of an east-west road from the eastern campus boundary across Mill Creek to the western portion of the campus where most development activity would occur. The major route to this access point would be from the south along N.E. 50th Avenue, Salmon Creek Avenue and N.E. 134th Street. Access to N.E. 179th Street would also be available by traveling north along N.E. 50th Avenue. 1998 and 2010 traffic projections including WSU traffic to/from this access location are presented in Appendix L, as are tables which summarize the intersection capacity analysis.

Future levels of service at key intersections in the study area with the N.E. 50th Avenue access alternative are depicted in Figure 21. Two intersections are expected to experience adverse traffic impacts in 1998. Eastbound traffic at the intersection of N.E. 134th Street with Salmon Creek Avenue is expected to experience LOS "E" during the AM peak hour. Northbound left turns at the intersection of N.E. 134th Street with the northbound I-205 off-ramp are expected to operate at LOS "F" during the PM peak hour. All other intersections will operate at LOS "D" or better during both the AM and PM peak hours.

In the year 2010, two intersections are expected to operate at level of service "F" during both the AM and PM peak hours. These are the intersections of N.E. 134th Street with the northbound I-205 off-ramp (for northbound left turns) and with Salmon Creek Avenue (for eastbound traffic). Additionally, during the PM peak hour, the intersections of N.E. 134th Street with the northbound I-5 off-ramp and Highway 99 are expected to operate at LOS "E" or "F". All other intersections will operate at LOS "D" or better during both the AM and PM peak hours.

#### ANALYSIS OF N.E. 29th AVENUE ACCESS TO/FROM SOUTH ONLY

As noted previously, access to the campus site from N.E. 29th Avenue would be taken at a point south of N.E. 150th Avenue and north of the southern end of the campus frontage on N.E. 29th



**FUTURE LEVELS OF SERVICE AT KEY INTERSECTIONS  
WITH WSU - N.E. 50TH AVENUE ACCESS**

**Kimley-Horn**

**FIGURE 21**

Avenue. For this alternative, the entrance point has been designed to preclude access to/from the north along N.E. 29th Avenue in order to protect the neighboring residential area from campus traffic intrusion. As with the earlier alternative, major access would be from the south along N.E. 29th Avenue, N.E. 139th Street, N.E. 20th Avenue and N.E. 134th Street. 1998 and 2010 traffic projections including WSU traffic to/from this access location are presented in Appendix N, as are tables which summarize the intersection capacity analysis.

Figure 22 shows future levels of service at key intersections in the study area with access to/from the south only on N.E. 29th Avenue. In 1998, this access alternative will not adversely impact most of the key intersections in the study area. The exceptions would be northbound left turns at the intersection of N.E. 134th Street with the northbound I-205 off-ramp which would experience LOS "F" during the PM peak hour, and westbound traffic at the intersection of N.E. 139th Street with N.E. 20th Avenue also during the PM peak hour. All other intersections will operate at LOS "D" or better during both the AM and PM peak hours.

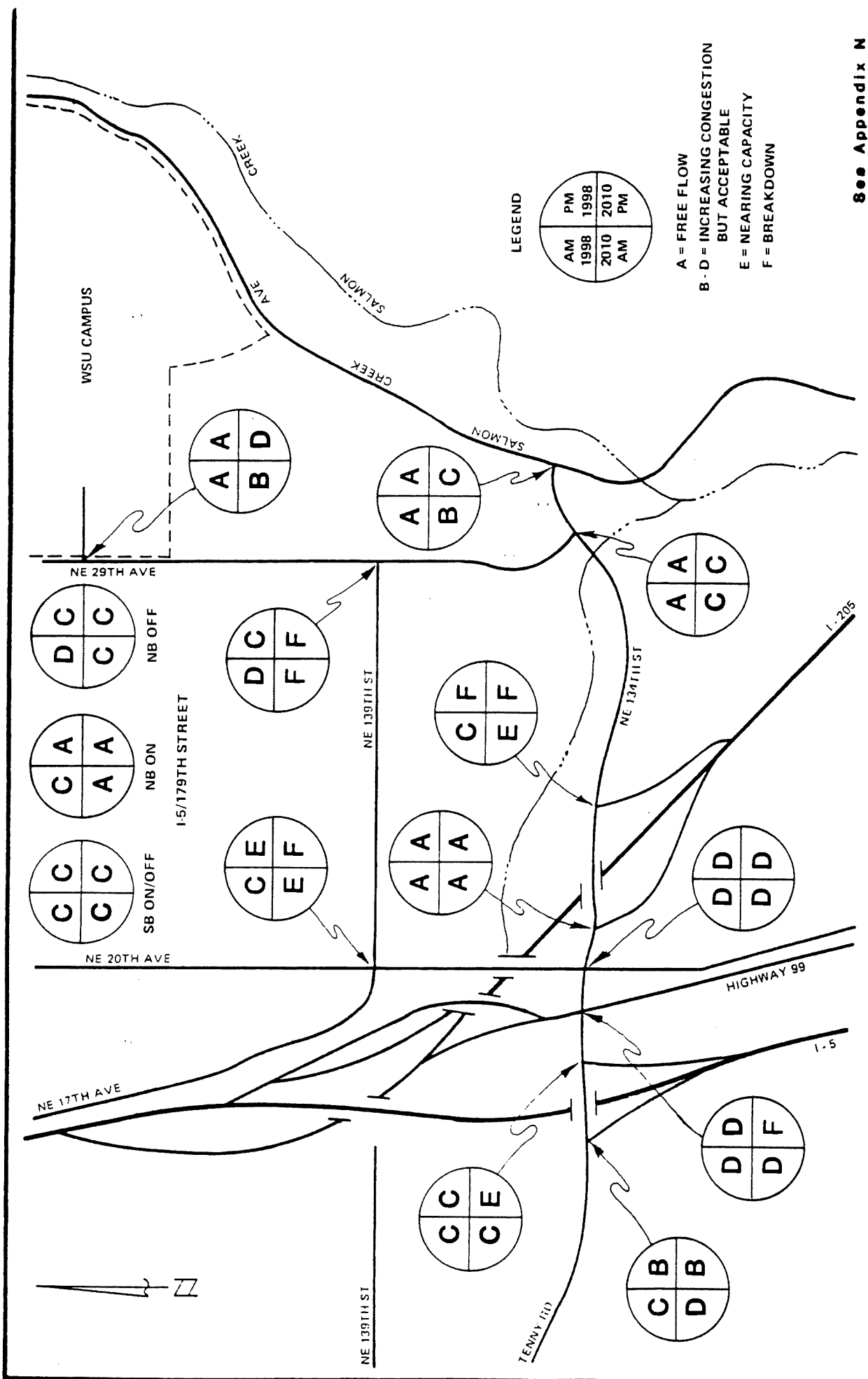
By 2010, several intersections are expected to operate at levels of service "E" or "F" during both the AM and PM peak hours. These include the intersection of N.E. 134th Street with the northbound I-205 off-ramp (for northbound left turns), and the intersections of N.E. 139th Street with N.E. 20th Avenue (for westbound traffic) and N.E. 29th Avenue (for eastbound traffic). All other intersections are expected to operate at an acceptable level of service during both the AM and PM peak hours.

#### ANALYSIS OF ACCESS AT BOTH SALMON CREEK AVENUE AND N.E. 29th AVENUE TO/FROM SOUTH ONLY

In this alternative, access to the WSU campus could be taken from both Salmon Creek and N.E. 29th Avenues at the general locations previously indicated. Access at N.E. 29th Avenue has been designed to preclude access to/from the north to minimize traffic impacts on the neighboring residential area.

The major routes to these access points would use N.E. 134th Street, Salmon Creek Avenue, N.E. 20th and 29th Avenues and N.E. 139th Street. 1998 and 2010 traffic projections including WSU traffic to/from this access location are presented in Appendix P, as are tables which summarize the intersection capacity analysis.

Figure 23 presents future levels of service at key intersections in the study area with access available from both Salmon Creek and N.E. 29th Avenues. During the PM peak hour in 1998, the intersection of N.E. 134th Street with the northbound I-205 off-ramp is expected to operate at LOS "F" (for northbound left

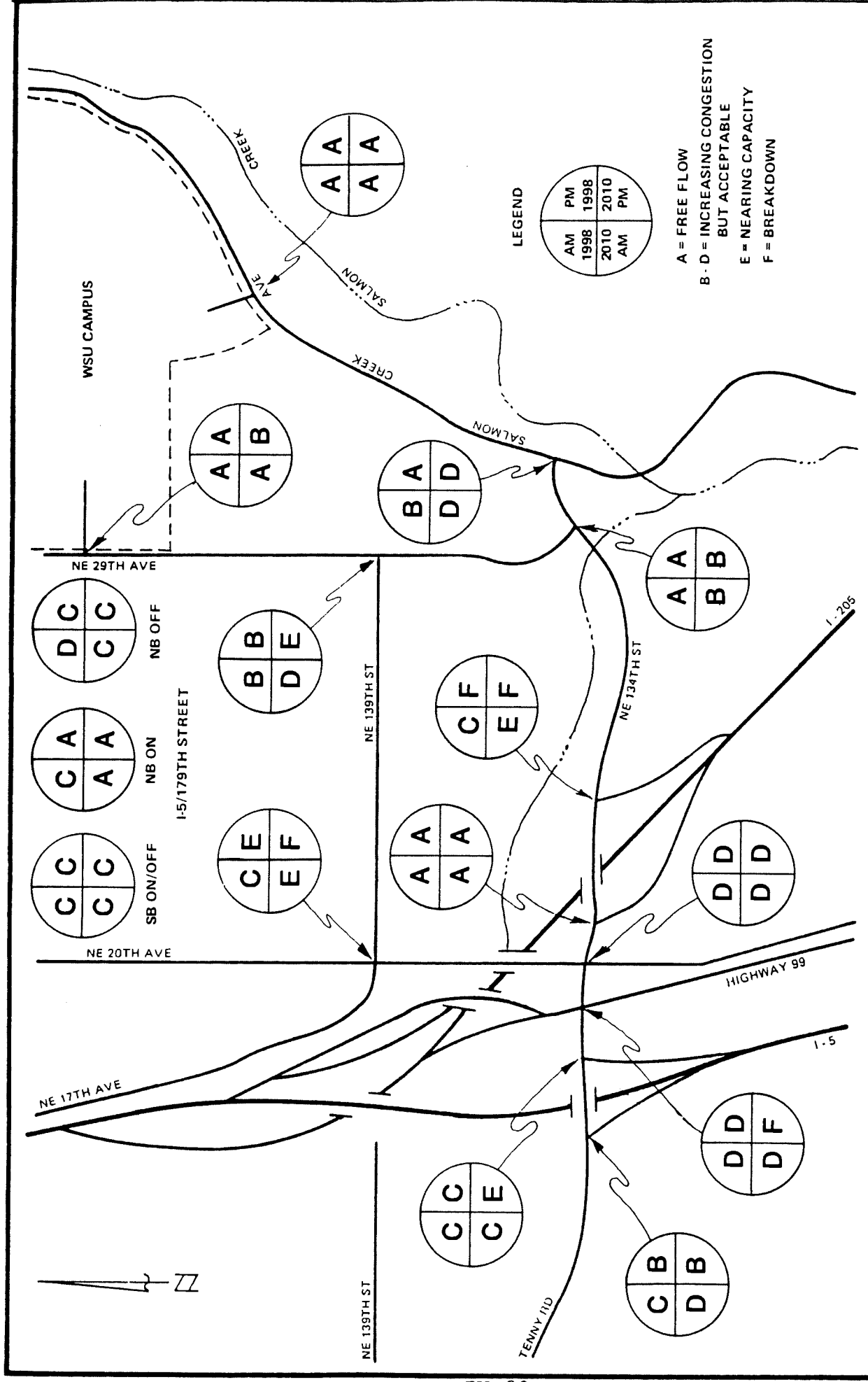


See Appendix N

**FUTURE LEVELS OF SERVICE AT KEY INTERSECTIONS  
 WITH WSU - N.E. 29TH AVENUE ACCESS  
 TO/FROM SOUTH ONLY**

**Kimley-Horn**

**FIGURE 22**



**Kimley-Horn**

**FUTURE LEVELS OF SERVICE AT KEY INTERSECTIONS WITH WSU ACCESS AT SALMON CREEK AVENUE AND N.E. 29TH AVENUE TO/FROM SOUTH ONLY**

**FIGURE 23**

turns), while the intersection of N.E. 20th Avenue with N.E. 139th Street is expected to operate at LOS "E" (for westbound traffic). All other intersections will operate at LOS "D" or better during both the AM and PM peak hours.

In 2010, the two intersections previously mentioned are expected to experience levels of service "E" or "F" during both the AM and PM peak hours. During the PM peak hour, LOS "E" and "F" will also be experienced at the intersections of N.E. 134th Street with the northbound I-5 off-ramp and Highway 99, and at the intersection of N.E. 139th Street with N.E. 29th Avenue.



## SECTION V

### MITIGATION

This section includes a discussion of the mitigation measures required with each access alternative to provide acceptable levels of service at the key intersections in the study area. Table 7 presents a summary of the roadway and intersection improvements required to mitigate WSU traffic impacts in 1998. Table 8 presents a summary of mitigation measures for 2010. It should be noted that these improvements would be in addition to those previously described in Section III for 1998 and 2010 background traffic conditions. It should also be noted that the 2010 improvements recommendations assume that those recommended in 1998 will be in place and/or upgraded as indicated.

The necessary mitigation measures associated with each access alternative are more fully discussed in the following sub-sections.

#### IMPROVEMENTS REQUIRED WITH SALMON CREEK AVENUE ACCESS

The following improvements have been identified as necessary to mitigate WSU traffic impacts with the Salmon Creek Avenue access alternative with Phase I development in 1998, and Phase II development in 2010. Level of service calculations for these improvements are presented in Appendix E.

##### Improvements to Mitigate WSU Traffic Impacts in 1998

Roadway improvements necessary by 1998 with the Salmon Creek Avenue access alternative are presented in Figure 24. These improvements include the following:

- Install a traffic signal at the intersection of N.E. 134th Street with the northbound I-205 off-ramp.
- Construct an additional eastbound approach lane on N.E. 134th Street at the intersection with Salmon Creek Avenue and installation of a three-way stop sign.
- Widen N.E. 134th Street to two 12-foot lanes with shoulders between Rockwell Drive and Salmon Creek Avenue. Some realignment of this roadway to improve turning radii at the intersection with N.E. 29th Avenue will also be required.
- Widen Salmon Creek Avenue in the vicinity of the WSU access road, and construct an eastbound left turn lane at the access road intersection. Install a stop sign on the WSU access road.

Table 7

## Mitigation Required for WSU Access Alternatives in 1998

Intersection/ Roadway	Alternative						
	Salmon Creek	29th Avenue	179th Street	29th/Salmon Creek Avenue	50th Avenue	29th Avenue to/from South	Salmon Ck./ 29th Ave. to/from So.
134th St. @ I-205 NB off-ramp	- Install signal	- Install signal	--	- Install signal	- Install signal	- Install signal	- Install signal
134th St, Rockwell to Salmon Creek	- Widen	--	--	- Widen	--	--	- Widen
134th St. @ 29th Avenue	- Improve	--	--	- Improve	--	--	- Improve
134th @ Salmon Creek	- Install 3- way stop	--	--	- Improve SB sight distance	- Install 3- way stop	--	- Improve SB sight distance
Salmon Creek @ WSU Access	- Widen - Add EBL	--	--	- Widen - Add EBL	--	--	- Widen - Add EBL
139th Street, 20th to 29th	--	- Widen	--	- Widen	--	- Widen	- Widen
139th St. @ 20th Avenue	--	--	--	--	--	- Install 4-way stop - Add NBL/ SBL	- Install 4-way stop - Add NBL/ SBL
29th Ave., 139th to WSU Access	--	- Widen	--	- Widen	--	- Widen	- Widen

Table 7 Continued

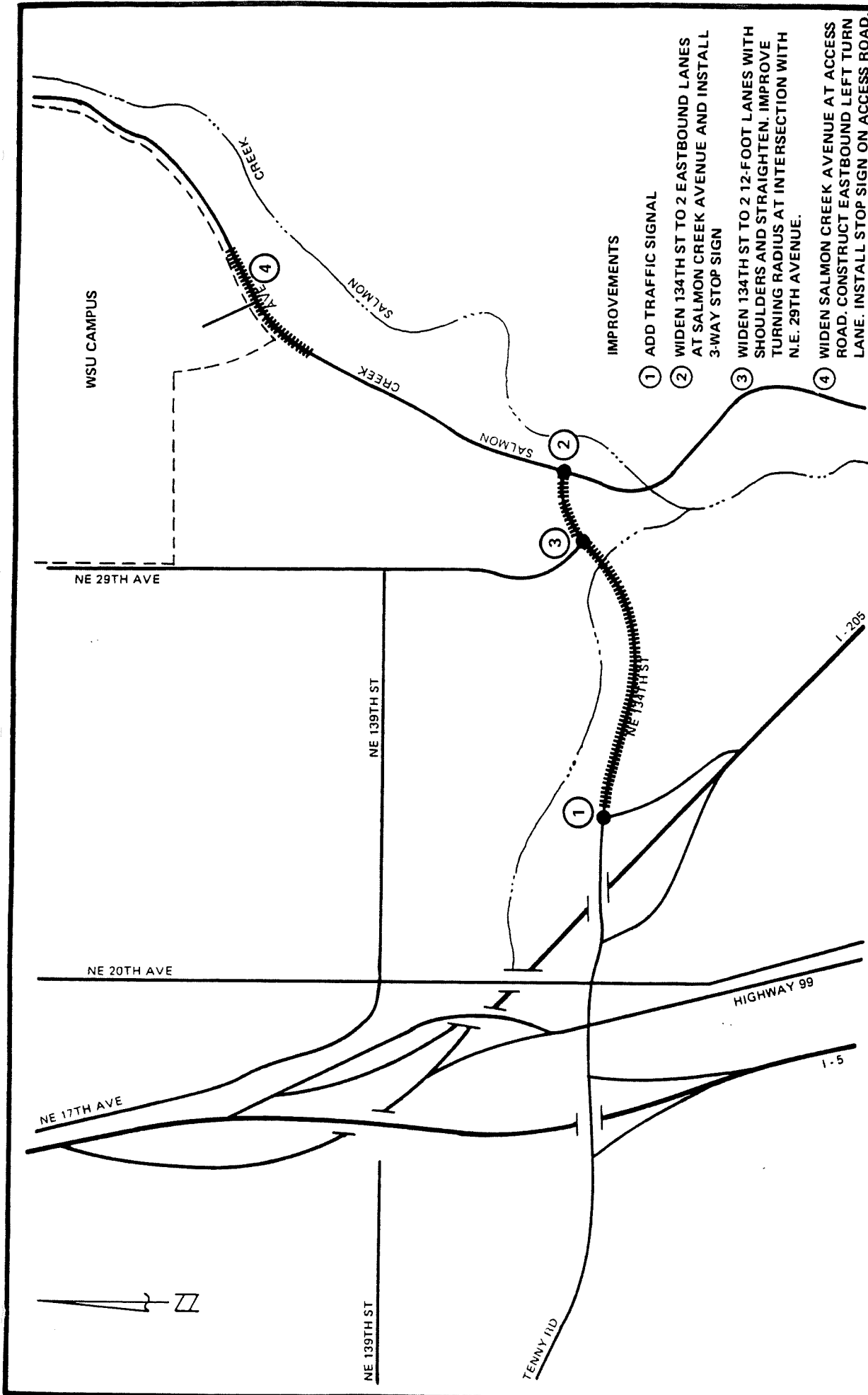
## Mitigation Required for WSU Access Alternatives in 1998

Intersection/ Roadway	Alternative						
	Salmon Creek	29th Avenue	179th Street	29th/Salmon Creek Avenue	50th Avenue	29th Avenue to/from South	Salmon Ck./ 29th Ave. to/from So.
29th Ave. @ WSU Access	--	- Install stop sign on access road	--	- Install stop sign on access road	--	- Install stop sign on access road	- Install stop sign on access road
179th St. @ WSU Access	--	--	- Construct access road - Install stop sign on access road - Widen - Add WBL	--	--	--	--
50th Ave. @ WSU Access	--	--	--	--	- Widen - Add NBL - Install stop sign on access road	--	--

Table 8

## Mitigation Required for WSU Access Alternatives in 2010

Intersection/ Roadway	Alternative						
	Salmon Creek	29th Avenue	179th Street	29th/Salmon Creek Avenue	50th Avenue	29th Avenue to/from South	Salmon Ck./ 29th Ave. to/from So.
134th St. @ Hwy 99	- Improve	- Improve	- Improve	- Improve	- Improve	- Improve	- Improve
134th St. @ 29th Avenue	- Add EBL - Install signal	--	--	--	- Install signal	--	--
134th St. @ Salmon Creek	- Install signal - Widen for EBL/EBR	--	--	--	- Install signal - Widen for EBL/EBR	--	--
139th St. @ 20th Avenue	--	- Install signal - Add NBL/ SBL	--	- Install signal - Add NBL/ SBL	--	- Install signal - Add NBL/ SBL	- Install signal - Add NBL/ SBL
139th St. @ 29th Avenue	--	- Install 3- way stop - Add NBL/ SBR	--	--	--	- Install signal - Add NBL/ SBR	- Install signal - Add NBL/ SBR
29th Ave. @ WSU Access	--	- Install 3- way stop - Add NBR/ SBL	--	--	--	--	--
50th Ave. @ WSU Access	--	--	--	--	- Add SBR only	--	--



NECESSARY ROADWAY IMPROVEMENTS BY 1998  
WITH WSU-SALMON CREEK AVENUE ACCESS

FIGURE 24

Kimley-Horn

### Improvements to Mitigate WSU Traffic Impacts in 2010

With this access alternative, some additional roadway or intersection improvements will be required by 2010. These improvements are shown in Figure 25 and include the following:

- Widen N.E. 134th Street in the vicinity of the intersection with N.E. 29th Avenue, construct an eastbound left turn lane at the intersection and install a traffic signal.
- Install a traffic signal at the intersection of N.E. 134th Street with Salmon Creek Avenue.
- Reconfigure the intersection of N.E. 134th Avenue with Highway 99. This includes addition of a second southbound through lane and elimination of the existing free eastbound right turn movement. This improvement would be in addition to the pending improvements discussed in Section III and was identified as the most readily implementable action to provide level of service "D" operations.

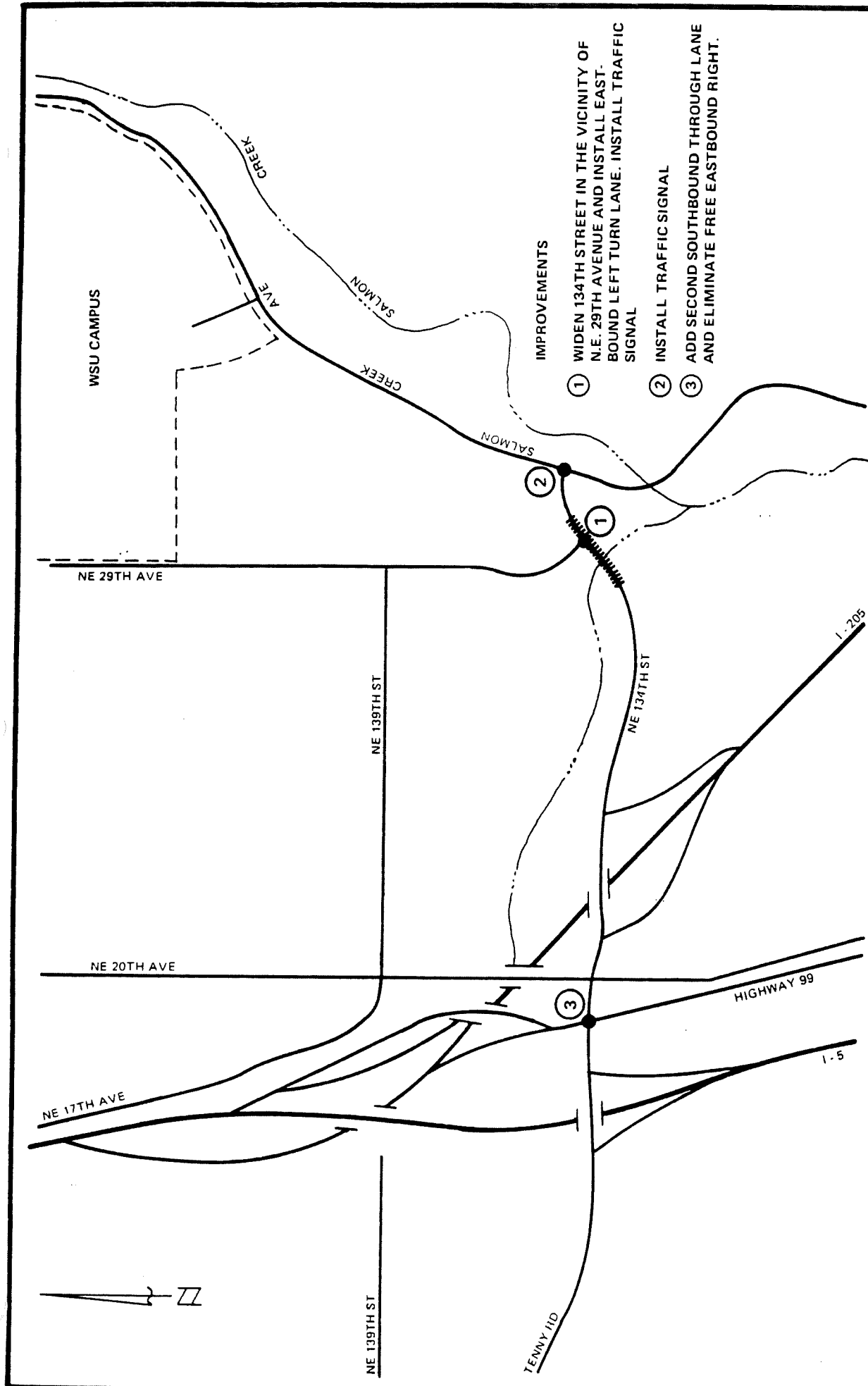
### **IMPROVEMENTS REQUIRED WITH N.E. 29th AVENUE ACCESS**

The following improvements have been identified as necessary to mitigate WSU traffic impacts with the N.E. 29th Avenue access alternative with Phase I development in 1998, and Phase II development in 2010. Level of service calculations for these improvements are presented in Appendix G.

### Improvements to Mitigate WSU Traffic Impacts in 1998

Roadway improvements necessary by 1998 with the N.E. 29th Avenue access alternative are shown in Figure 26. These improvements include the following:

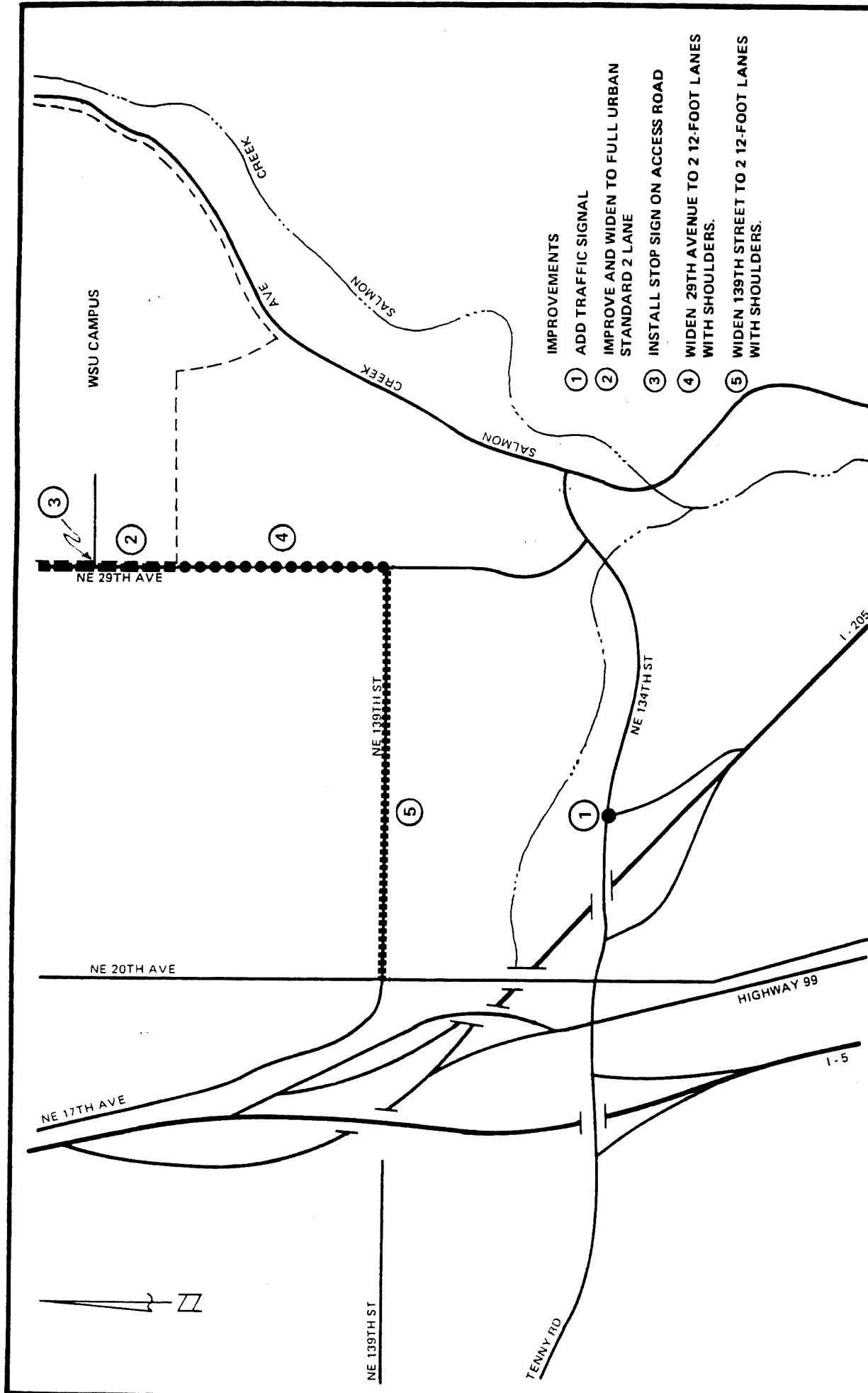
- Install a traffic signal at the intersection of N.E. 134th Street with the northbound I-205 off-ramp.
- Widen of N.E. 139th Street between N.E. 20th and N.E. 29th Avenues to two 12-foot lanes with 6-foot shoulders. Improve intersection of N.E. 139th Street and N.E. 29th Avenue to accommodate turning radii requirements of at 40-foot transit coaches.
- Improve and widen N.E. 29th Avenue to a full urban standard two-lane facility along WSU frontage.
- Widen N.E. 29th Avenue to 2 12-foot lanes with 6-foot shoulders south of WSU frontage to vicinity of N.E. 139th Street.
- Install a stop sign on the WSU access road at N.E. 29th Avenue.



**ADDITIONAL NECESSARY ROADWAY IMPROVEMENTS BY 2010  
WITH WSU-SALMON CREEK AVENUE ACCESS**

**Kimley-Horn**

**FIGURE 25**



NECESSARY ROADWAY IMPROVEMENTS BY 1998  
WITH WSU-N.E. 29TH AVENUE ACCESS

Kimley-Horn

FIGURE 26



### Improvements to Mitigate WSU Traffic Impacts in 2010

With this access alternative, some additional roadway or intersection improvements will be required by 2010. These improvements are shown in Figure 27 and include the following:

- Reconfigure the intersection of N.E. 134th Avenue with Highway 99. This includes the addition of a second southbound through lane and elimination of the existing free eastbound right turn movement.
- Install a traffic signal and add north and southbound left turn lanes at the intersection of N.E. 20th Avenue with N.E. 139th Street.
- Construct northbound left and southbound right turn lanes at the intersection of N.E. 29th Avenue with N.E. 139th Street. Stop signs should also be installed on all approaches to this intersection. It is not expected that traffic signal warrants would be met.

### **IMPROVEMENTS REQUIRED WITH N.E. 179th STREET ACCESS**

The following improvements have been identified as necessary to mitigate WSU traffic impacts with the N.E. 179th Street access alternative with Phase I development in 1998, and Phase II development in 2010. Level of service calculations for these improvements are presented in Appendix I.

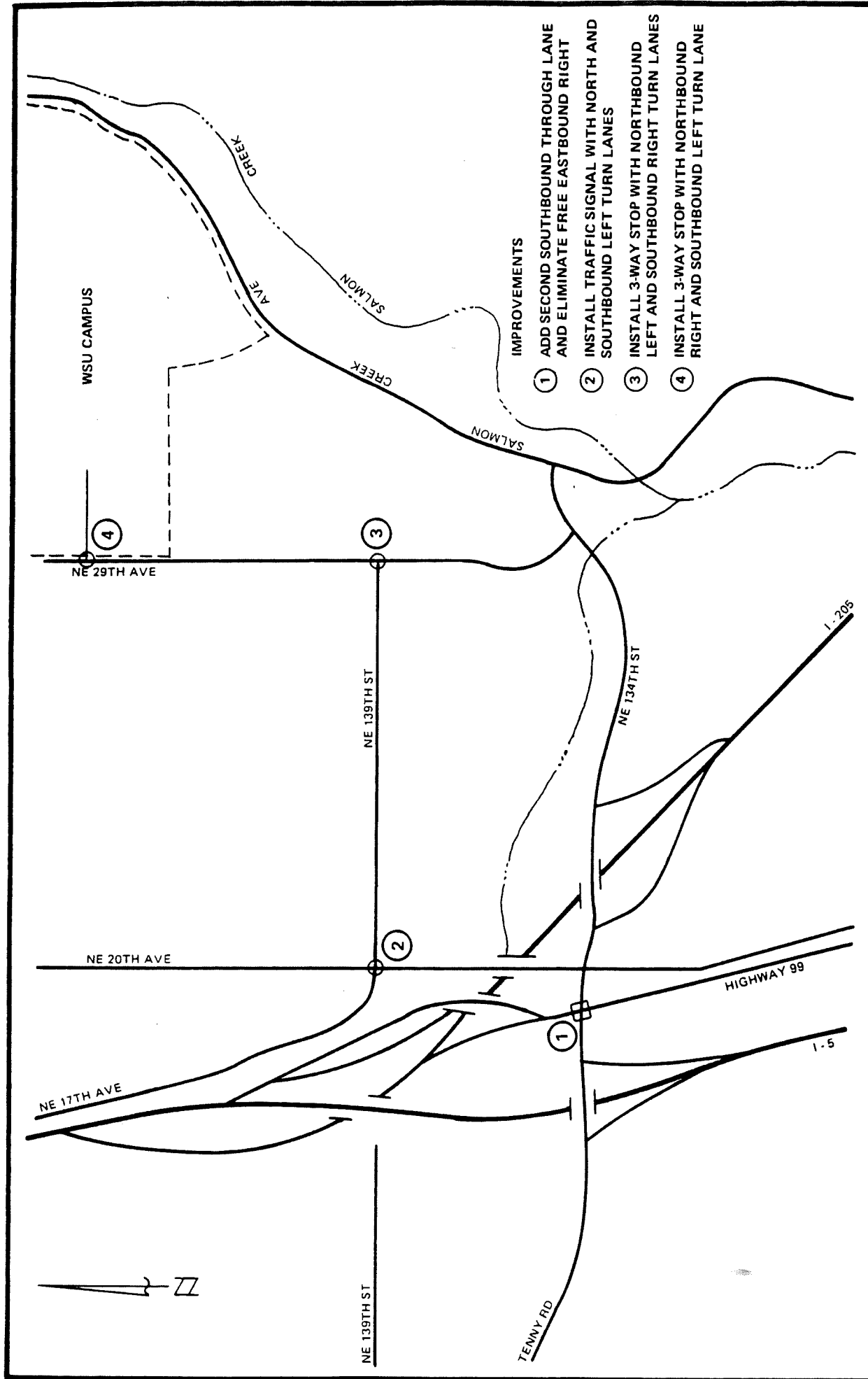
### Improvements to Mitigate WSU Traffic Impacts in 1998

Roadway improvements necessary by 1998 with the N.E. 179th Street access alternative are shown in Figure 28. These improvements include the following:

- Construct an access road between the campus and N.E. 179th Street. This access road would be approximately 0.9 miles in length. Installation of a stop sign on the access road at N.E. 179th Street is also recommended.
- Improve N.E. 179th Street in the vicinity of the access road to provide adequate sight distance and turn channelization.

### Improvements to Mitigate WSU Traffic Impacts in 2010

With this access alternative, one additional intersection improvement will be required by 2010. This improvement is shown in Figure 29 and involves reconfiguring the intersection of N.E. 134th Avenue at Highway 99. This reconfiguration includes the addition of a second southbound through lane and elimination of the existing free eastbound right turn movement.



ADDITIONAL NECESSARY ROADWAY IMPROVEMENTS BY 2010  
WITH WSU-N.E. 29TH AVENUE ACCESS

Kimley-Horn

FIGURE 27





## IMPROVEMENTS REQUIRED WITH ACCESS VIA BOTH SALMON CREEK AND N.E. 29TH AVENUE

The following improvements have been identified as necessary to mitigate 1998 and 2010 WSU traffic impacts with access provided from both Salmon Creek and N.E. 29th Avenue. Level of service calculations for these improvements are presented in Appendix K.

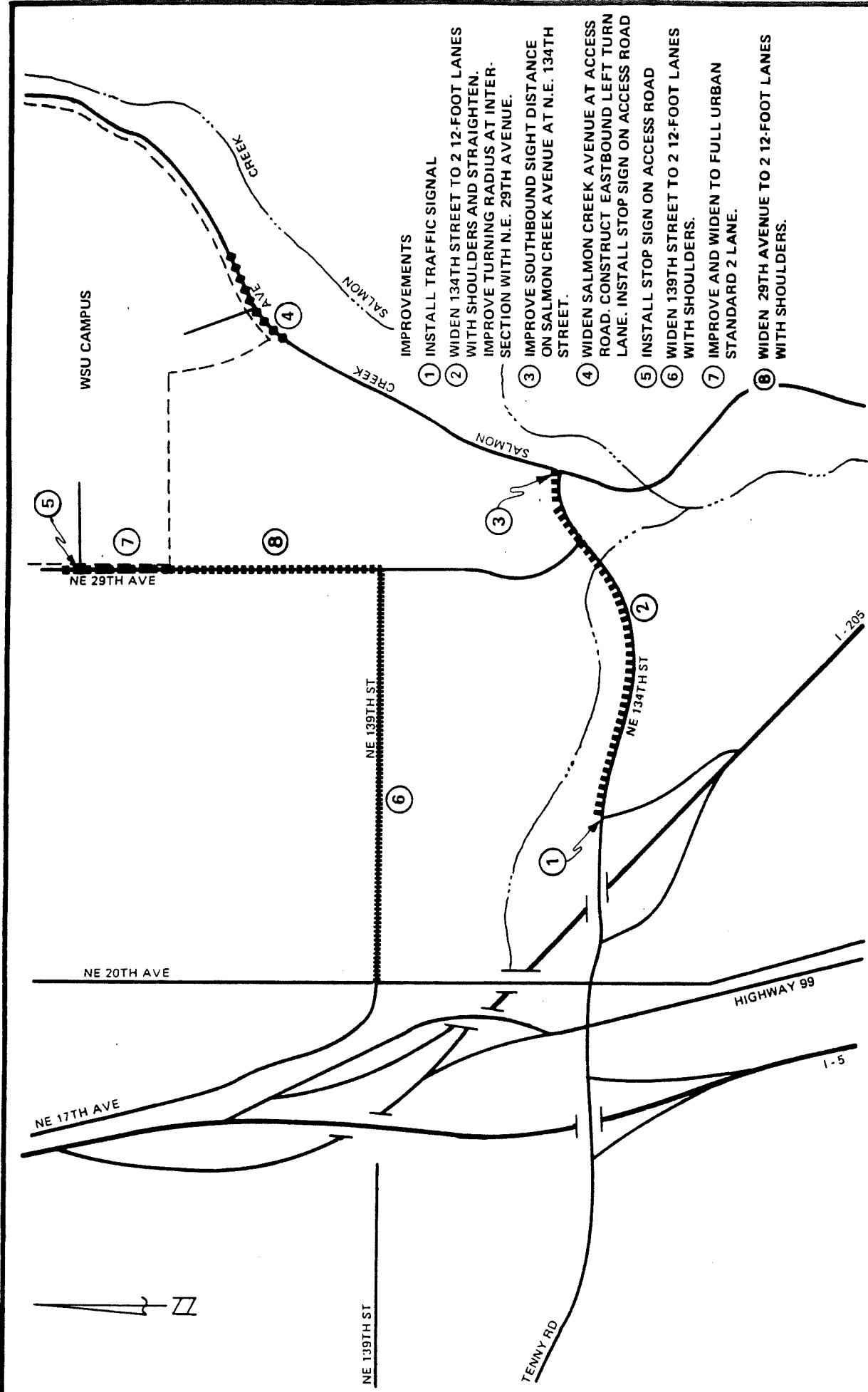
### Improvements to Mitigate WSU Traffic Impacts in 1998

Roadway improvements necessary by 1998 with access provided from both Salmon Creek and N.E. 29th Avenues are shown in Figure 30. These improvements include the following:

- Install a traffic signal at the intersection of N.E. 134th Street with the northbound I-205 off-ramp.
- Widen N.E. 134th Street to two 12-foot lanes with 6-foot shoulders between Rockwell Drive and Salmon Creek Avenue. Some realignment of this roadway to improve turning radii in the vicinity of the intersection with N.E. 29th Avenue will also be required.
- Improve southbound sight distance on Salmon Creek Avenue at N.E. 134th Street.
- Widen Salmon Creek Avenue in the vicinity of the WSU access road and construct an eastbound left turn lane at the intersection. Install a stop sign on the WSU access road at Salmon Creek Avenue.
- Widen N.E. 139th Street between N.E. 20th and N.E. 29th Avenues to two 12-foot lanes with 6-foot shoulders. Improve intersection of N.E. 139th Street and N.E. 29th Avenue to accommodate turning radii requirements of at 40-foot transit coaches.
- Improve and widen N.E. 29th Avenue to a full urban standard two-lane facility along WSU frontage.
- Widen N.E. 29th Avenue to 2 12-foot lanes with 6-foot shoulders south of WSU frontage to vicinity of N.E. 139th Street.
- Install a stop sign on the WSU access road at N.E. 29th Avenue.

### Improvements to Mitigate WSU Traffic Impacts in 2010

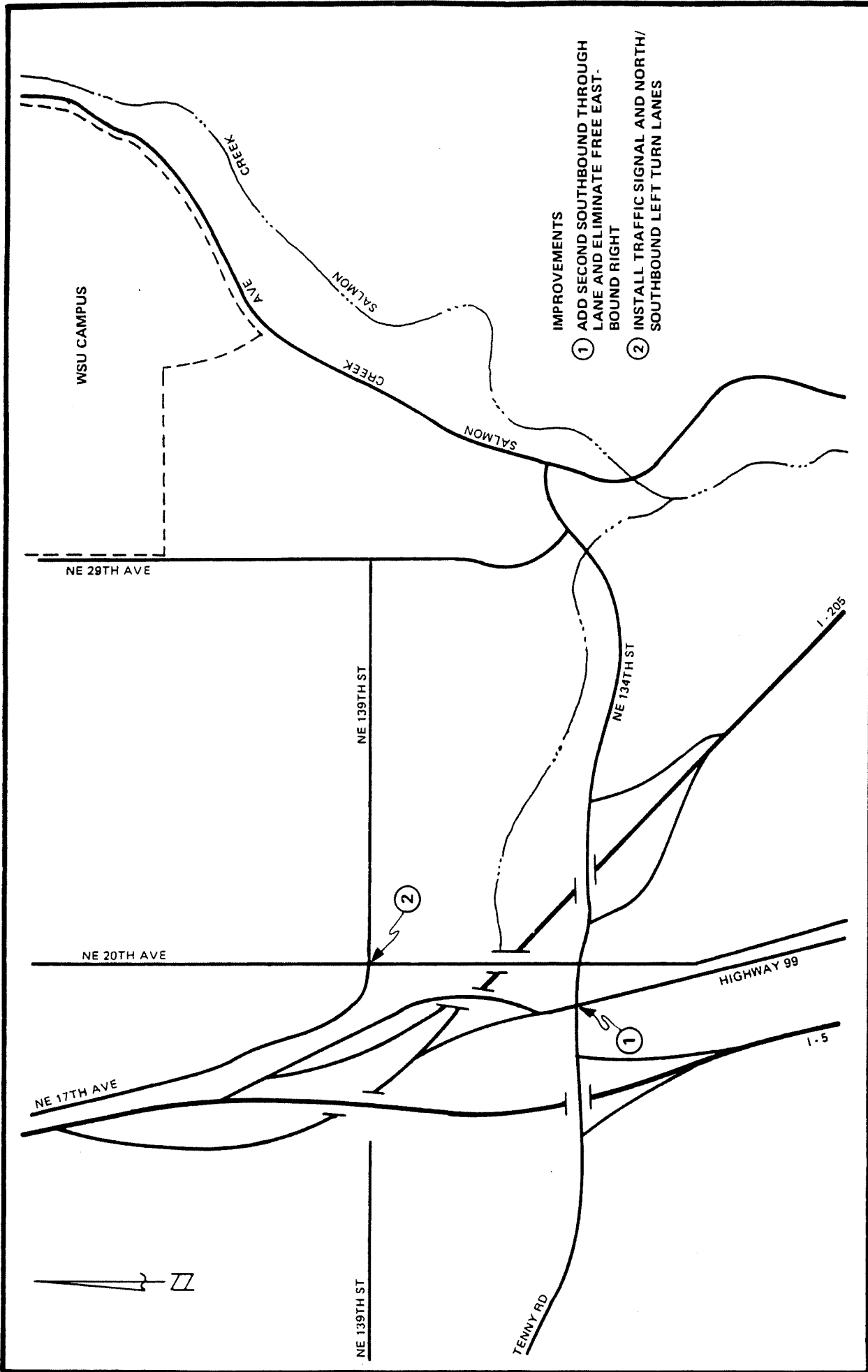
With this access alternative, some additional roadway or intersection improvements will be required by 2010. These improvements are shown in Figure 31 and include the following:



**NECESSARY ROADWAY IMPROVEMENTS BY 1998  
WITH WSU - SALMON CREEK AND N.E. 29TH AVENUE ACCESS**

**Kimley-Horn**

**FIGURE 30**



ADDITIONAL NECESSARY ROADWAY IMPROVEMENTS BY 2010  
WITH WSU - SALMON CREEK AND N.E. 29TH AVENUE ACCESS

FIGURE 31

**Kimley-Horn**

- Reconfigure the intersection of N.E. 134th Avenue with Highway 99. This includes the addition of a second southbound through lane and elimination of the existing free eastbound right turn movement.
- Install a traffic signal and add north and southbound left turn lanes at the intersection of N.E. 20th Avenue with N.E. 139th Street.

#### IMPROVEMENTS REQUIRED WITH N.E. 50th AVENUE ACCESS

The following improvements have been identified as necessary to mitigate WSU traffic impacts with the N.E. 50th Avenue access alternative with Phase I development in 1998, and Phase II development in 2010. Level of service calculations for these improvements are presented in Appendix M.

##### Improvements to Mitigate WSU Traffic Impacts in 1998

Roadway improvements necessary by 1998 with the N.E. 50th Avenue access alternative are shown in Figure 32. These improvements include the following:

- Improve N.E. 50th Avenue in the vicinity of the WSU access location to provide for northbound left turn channelization. Install a stop sign on the WSU access road at N.E. 50th Avenue.
- Install stop signs on all approaches to the intersection of N.E. 134th Street with Salmon Creek Avenue.
- Install a traffic signal at the intersection of N.E. 134th Street with the northbound I-205 off-ramp.

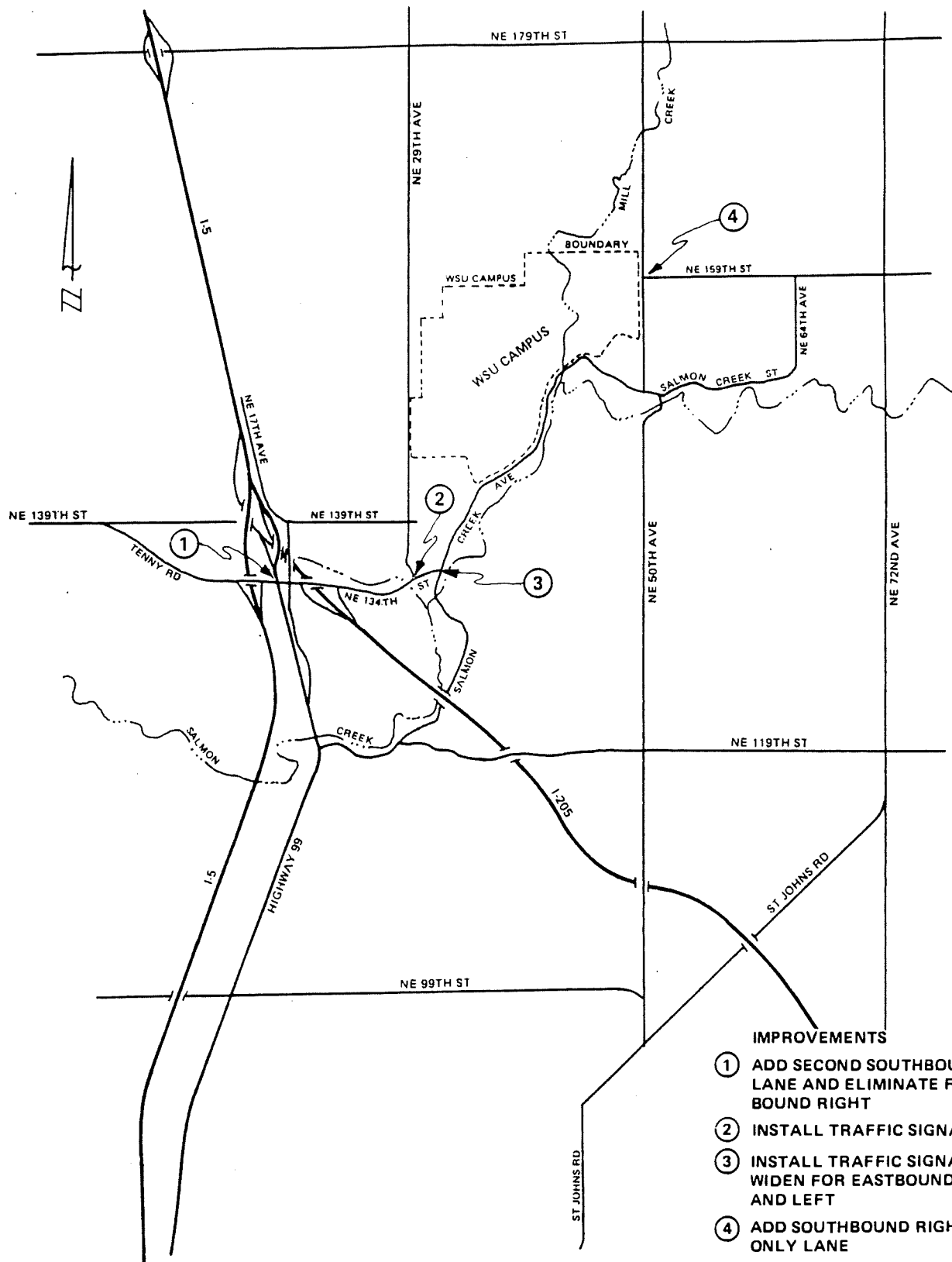
##### Improvements to Mitigate WSU Traffic Impacts in 2010

With this access alternative, some additional roadway or intersection improvements will be required by 2010. These improvements are shown in Figure 33 and include the following:

- Reconfigure the intersection of N.E. 134th Avenue with Highway 99. This includes the addition of a second southbound through lane and elimination of the existing free eastbound right turn movement.
- Install a traffic signal at the intersection of N.E. 134th Street with N.E. 29th Avenue and improve turning radii and sight distance at this location.







**FIGURE 33**

**ADDITIONAL NECESSARY  
ROADWAY IMPROVEMENTS BY 2010  
WITH WSU – N.E. 50TH AVENUE ACCESS**

**Kimley-Horn**

Kimley-Horn and Associates, Inc.

- Widen N.E. 134th Street in the vicinity of Salmon Creek Avenue to allow construction of separate eastbound right and left turn lanes. Install a traffic signal at this intersection.
- Widen N.E. 50th Avenue north of the WSU access location to allow construction of a southbound right turn lane into the campus.

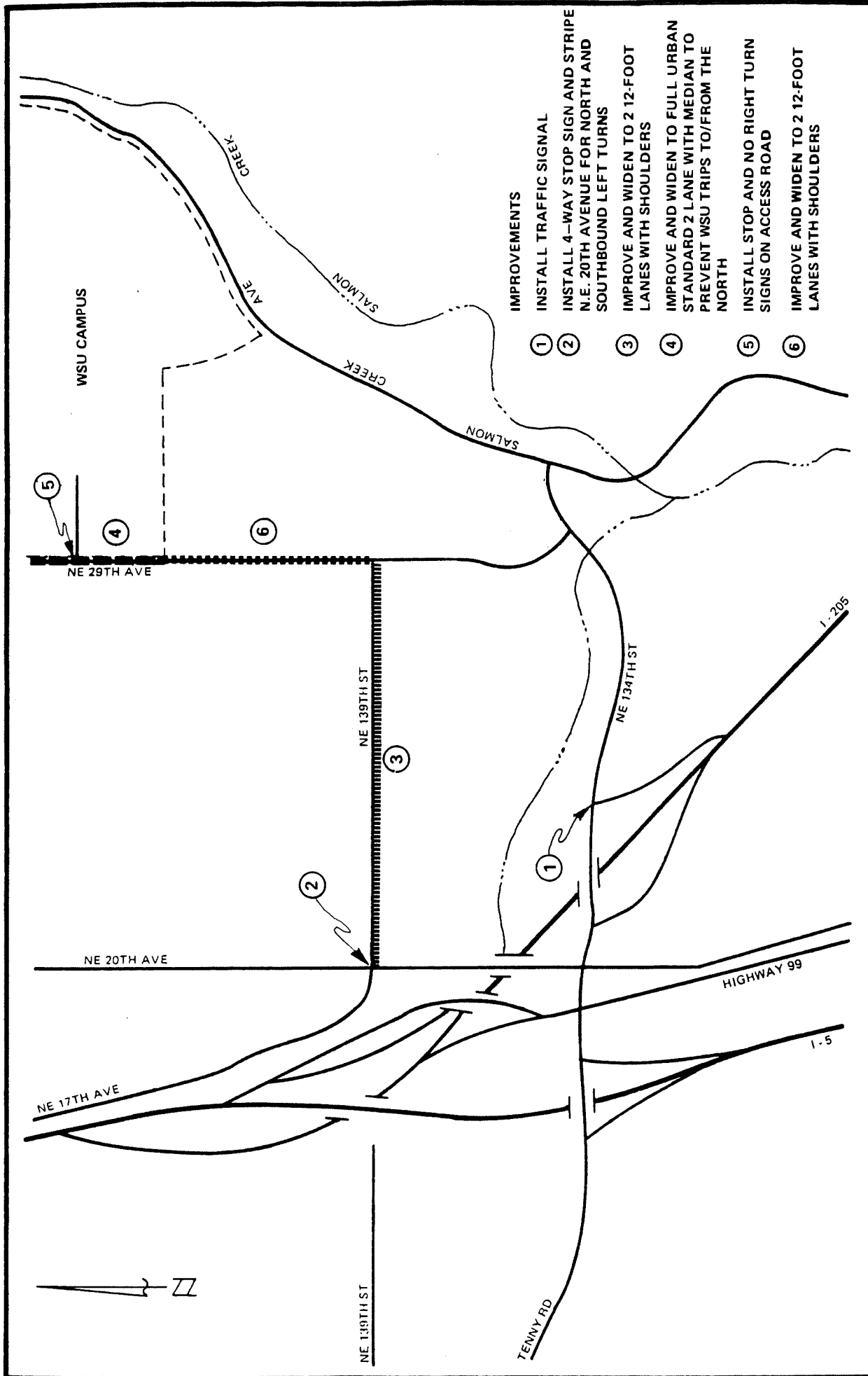
#### IMPROVEMENTS REQUIRED WITH N.E. 29th AVENUE ACCESS TO/FROM SOUTH ONLY

The following improvements have been identified as necessary to mitigate WSU traffic impacts with access to and from the south only on N.E. 29th Avenue. Level of service calculations for these improvements are presented in Appendix O.

#### Improvements to Mitigate WSU Traffic Impacts in 1998

Roadway improvements necessary by 1998 with access provided to and from the south only on N.E. 29th Avenue, are shown in Figure 34. These improvements include the following:

- Install a traffic signal at the intersection of N.E. 134th Street with the northbound I-205 off-ramp.
- Construct north- and southbound left turn lanes at the intersection of N.E. 20th Avenue with N.E. 139th Street. Install stop signs on all approaches to this intersection.
- Widen of N.E. 139th Street between N.E. 20th and N.E. 29th Avenue to two 12-foot lanes with 6-foot shoulders.
- Configure intersection of WSU egress road with N.E. 29th Avenue and install median such that eastbound right turns and southbound left turns to/from the campus cannot be made. Install a stop sign on the WSU access road and other appropriate signing to prevent campus traffic from using N.E. 29th Avenue to the north.
- Improve and widen N.E. 29th Avenue to a full urban standard two-lane facility along WSU frontage and where needed to facilitate transitions around median on N.E. 29th Avenue at WSU access/egress roads.
- Widen N.E. 29th Avenue to 2 12-foot lanes with 6-foot shoulders south of WSU frontage to vicinity of N.E. 139th Street.



**NECESSARY ROADWAY IMPROVEMENTS BY 1998**  
**WITH WSU - N.E. 29TH AVENUE ACCESS TO/FROM SOUTH ONLY**

**Kimley-Horn**

**FIGURE 34**

### Improvements to Mitigate WSU Traffic Impacts in 2010

With this access alternative, some additional roadway or intersection improvements will be required by 2010. These improvements are shown in Figure 35 and include the following:

- Reconfigure the intersection of N.E. 134th Avenue with Highway 99. This includes the addition of a second southbound through lane and elimination of the existing free eastbound right turn movement.
- Install a traffic signal at the intersection of N.E. 20th Avenue with N.E. 139th Street.
- Install a traffic signal at the intersection of N.E. 29th Avenue with N.E. 139th Street.

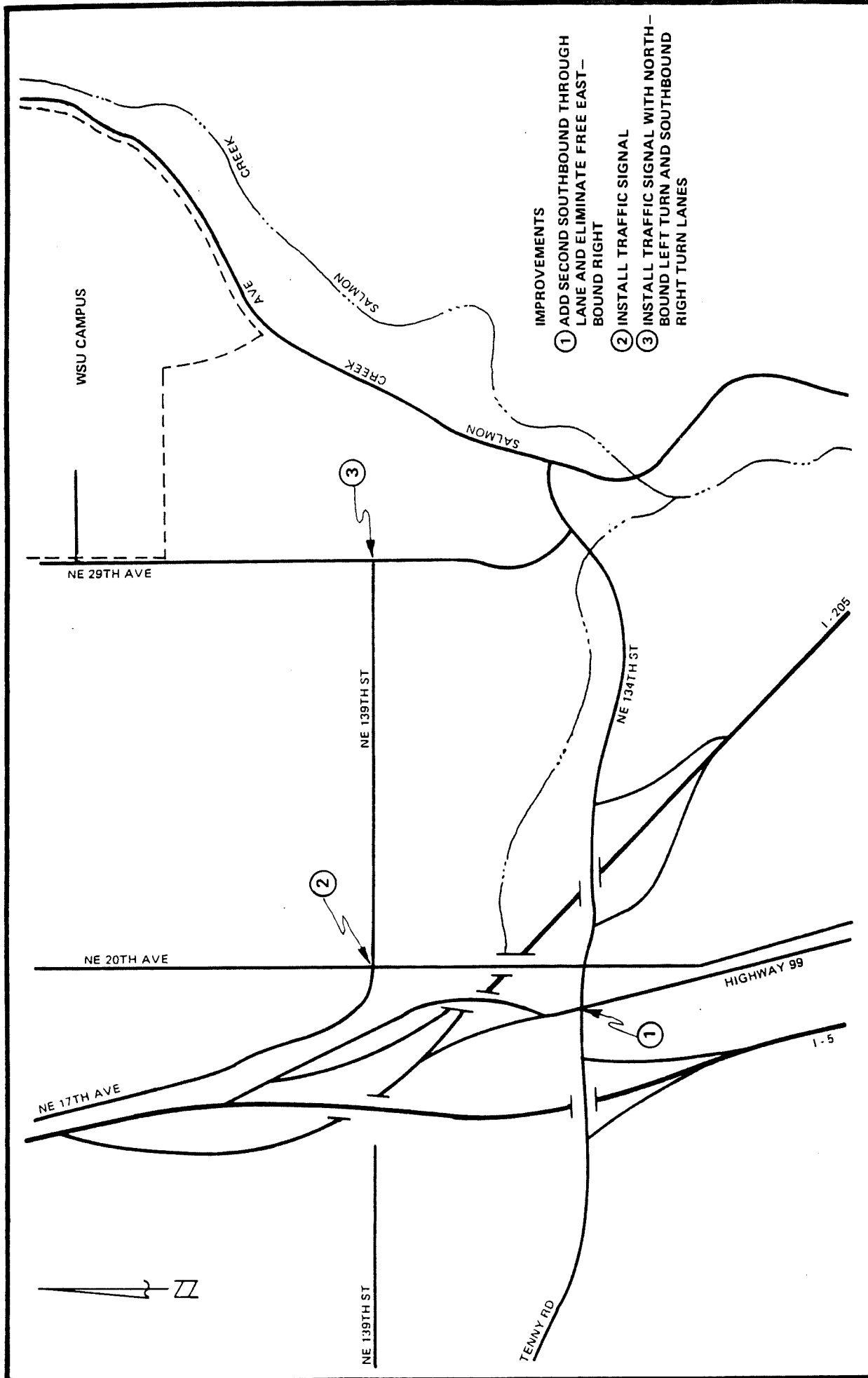
### **IMPROVEMENTS REQUIRED WITH ACCESS AT SALMON CREEK AVENUE AND N.E. 29th AVENUE TO/FROM SOUTH ONLY**

The following improvements have been identified as necessary to mitigate WSU traffic impacts with access at Salmon Creek Avenue and to/from the south only on N.E. 29th Avenue. Level of service calculations for these improvements are presented in Appendix Q.

### Improvements to Mitigate WSU Traffic Impacts in 1998

Roadway improvements necessary by 1998 with access provided at Salmon Creek and N.E. 29th Avenues (to/from south only), are shown in Figure 36. These improvements include the following:

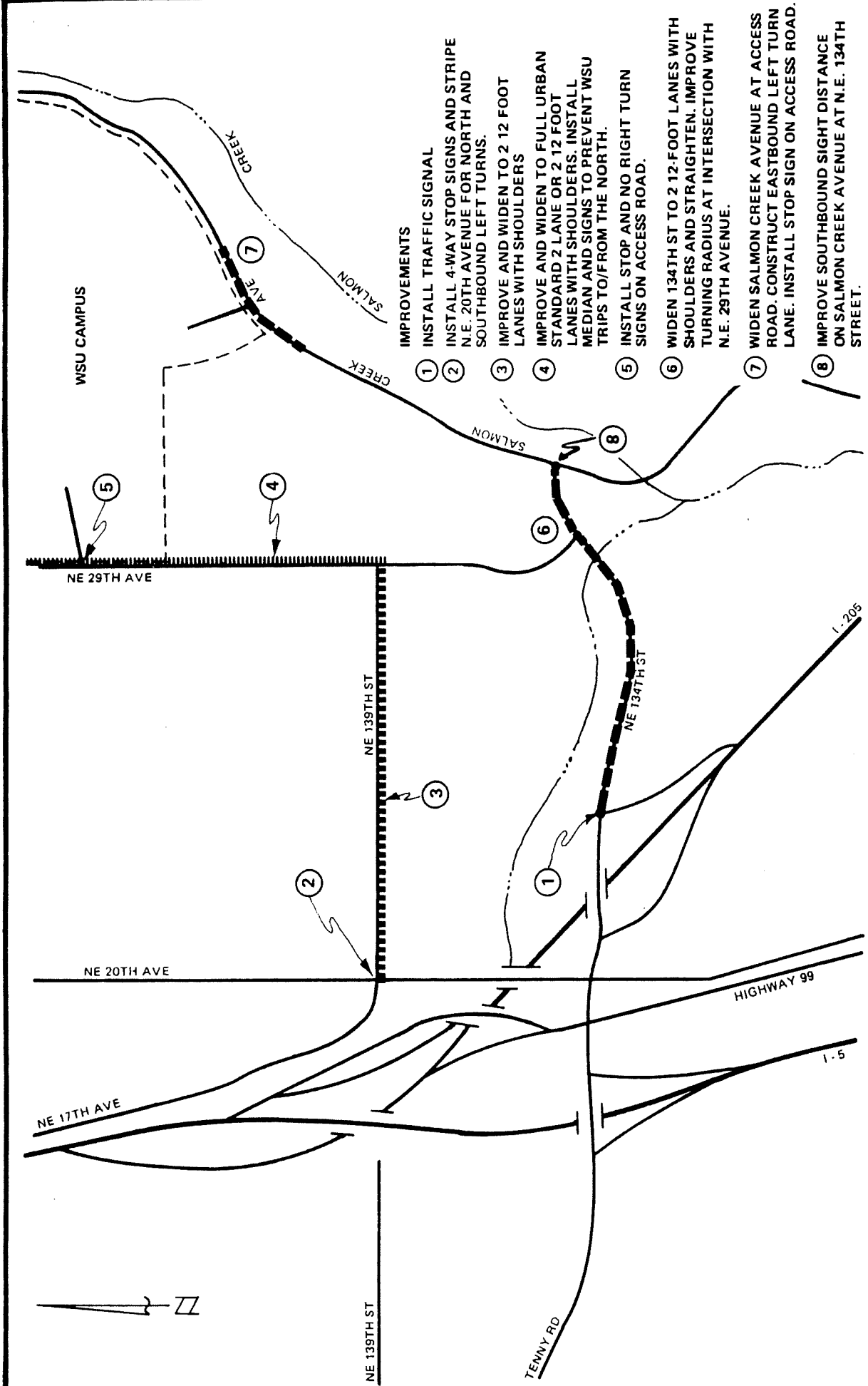
- Install a traffic signal at the intersection of N.E. 134th Street with the northbound I-205 off-ramp.
- Delineate north and southbound left turn lanes at the intersection of N.E. 20th Avenue with N.E. 139th Street. Install stop signs on all approaches to this intersection.
- Widen of N.E. 139th Street between N.E. 20th and N.E. 29th Avenue to two 12-foot lanes with 6-foot shoulders. Improve intersection of N.E. 139th Street and N.E. 29th Avenue to accommodate turning radii requirements of at 40-foot transit coaches.
- Configure intersection of WSU egress road with N.E. 29th Avenue and install median such that eastbound right turns and southbound left turns to/from the campus cannot be made. Install a stop sign on the WSU access road and other appropriate signing to prevent campus traffic from using N.E. 29th Avenue to the north.



**ADDITIONAL NECESSARY ROADWAY IMPROVEMENTS BY 2010  
WITH WSU - N.E. 29TH AVENUE ACCESS TO/FROM SOUTH ONLY**

**Kimley-Horn**

**FIGURE 35**



**NECESSARY ROADWAY IMPROVEMENTS BY 1998  
WITH WSU ACCESS AT SALMON CREEK AVENUE AND  
N.E. 29TH AVENUE TO/FROM SOUTH ONLY**

**Kimley-Horn**

**FIGURE 36**

- Improve and widen N.E. 29th Avenue to a full urban standard two-lane facility along WSU frontage and where needed to facilitate transitions around median on N.E. 29th Avenue at WSU access/egress roads.
- Widen N.E. 29th Avenue to 2 12-foot lanes with 6-foot shoulders south of WSU frontage to vicinity of N.E. 139th Street.
- Widen N.E. 134th Street to two 12-foot lanes with shoulders between Rockwell Drive and Salmon Creek Avenue. Some realignment of this roadway to improve turning radii at the intersection with N.E. 29th Avenue will also be required.
- Improve southbound sight distance on Salmon Creek Avenue at N.E. 134th Street.
- Widen Salmon Creek Avenue in the vicinity of the WSU access road, and construct an eastbound left turn lane at the access road intersection. Install a stop sign on the WSU access road.

#### Improvements to Mitigate WSU Traffic Impacts in 2010

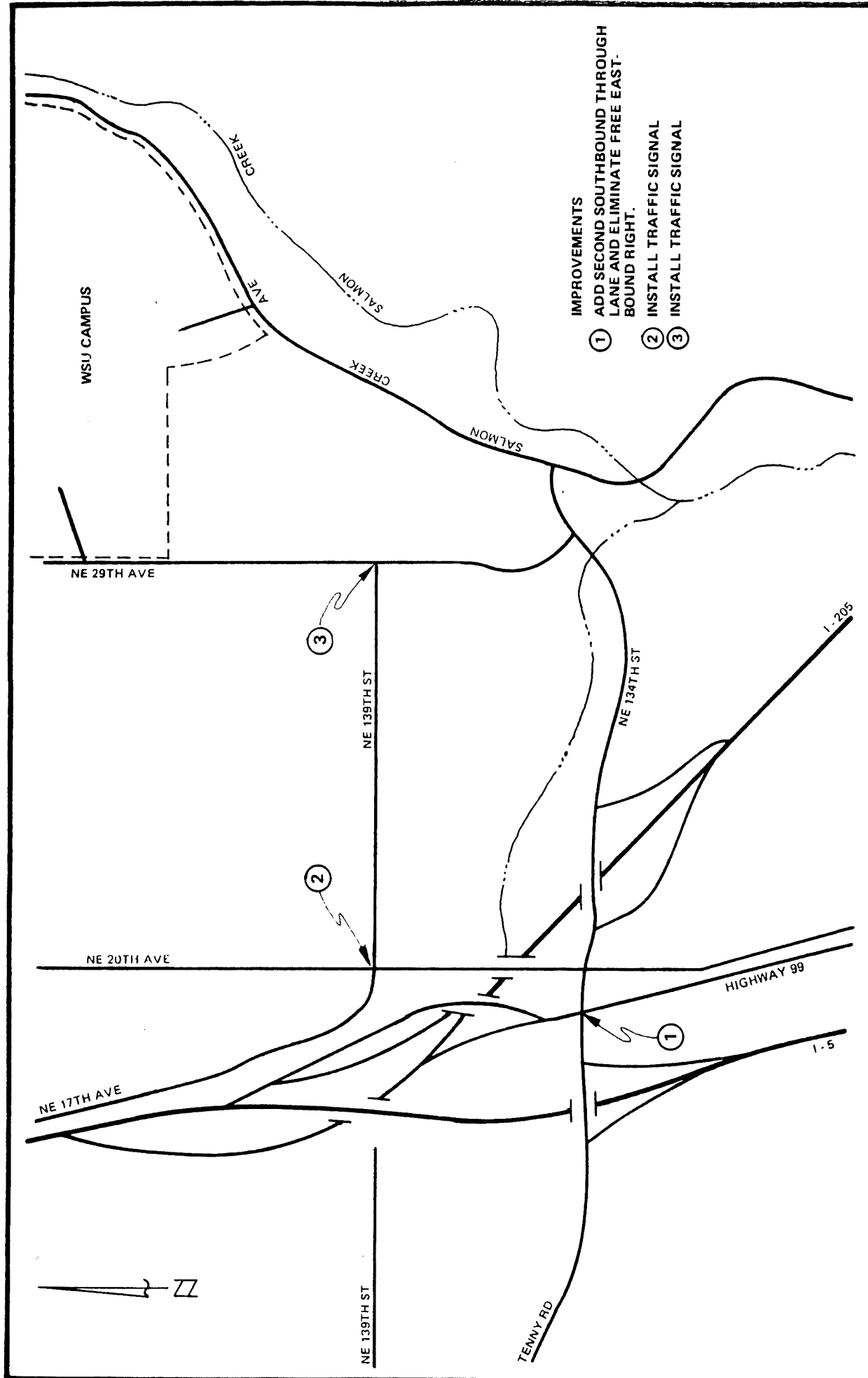
With this access alternative, some additional roadway or intersection improvements will be required by 2010. These improvements are shown in Figure 37 and include the following:

- Reconfigure the intersection of N.E. 134th Avenue with Highway 99. This includes the addition of a second southbound through lane and elimination of the existing free eastbound right turn movement.
- Install a traffic signal at the intersection of N.E. 20th Avenue with N.E. 139th Street. Provide north and southbound left turn lanes on N.E. 20th Avenue.
- Install a traffic signal at the intersection of N.E. 29th Avenue with N.E. 139th Street.

#### **TRANSPORTATION DEMAND MANAGEMENT**

In addition to the roadway improvements identified for Phases I and II, a series of transportation demand management strategies will be implemented to aid in mitigating the potential traffic impacts associated with campus development. Additionally, current state law requires that a Trip Reduction Program be developed for all employers with more than 100 employees on site. Target goals for these programs include a 15 percent reduction in trips from the 1992 baseline by 1995, with additional reductions in future years. At full Phase I development in 1998, WSU is expected to employ more than 100 persons on the campus and it is expected that a Trip Reduction Program will be required.





**ADDITIONAL NECESSARY ROADWAY IMPROVEMENTS BY 2010  
WITH WSU ACCESS AT SALMON CREEK AVENUE AND  
N.E. 29TH AVENUE TO/FROM SOUTH ONLY**

**Kimley-Horn**

**FIGURE 37**

The intent of a Trip Reduction Program and the implementation of various travel demand strategies is to reduce reliance on single-occupant automobiles as a means of access to the campus. Transportation demand management (TDM) strategies identified for consideration include:

- provision of direct public transit service to the campus site;
- development and implementation of a rideshare matching program for the campus;
- restriction on and/or management of auto parking on campus;
- development and construction of a bicycle and pedestrian circulation system to/from and within the campus including ancilliary facilities to encourage the use of these transportation modes.

Each of these strategies will be assessed to determine implementation feasibility and potential benefits for the WSU campus and surrounding street system.

Appendix A

Summary of Levels of Service for  
Existing, 1998 and 2010 Conditions  
Without Development of WSU Campus

## APPENDIX A

### Level of Service Analysis

Analysis of traffic operations at key intersections in the study area was conducted using methodologies outlined in the 1985 Highway Capacity Manual (HCM). According to the HCM, there are six levels of service (LOS) by which the operating performance of an intersection may be described. These levels of service range from LOS "A" which indicates a relatively free-flowing condition to LOS "F" which indicates operational breakdown. Level of service "D" has been identified by the County as the minimum acceptable standard. With this level of service, some delays are expected for certain traffic movements.

At signalized intersections, like N.E. 134th Street at Highway 99 and N.E. 179th Street at the northbound I-5 off-ramp, level of service is related to the average delay experienced by all vehicles as they approach the intersection. The following table summarizes the relationship between level of service and average delay.

<u>Level of Service</u>	<u>Average Delay (Seconds per Vehicle)</u>
A	< 5.0
B	5.1 - 15.0
C	15.1 - 25.0
D	25.1 - 40.0
E	40.1 - 60.0
F	> 60.0

At unsignalized intersections, which includes most of the intersections in the study area, level of service is related to reserve, or unused, roadway capacity (measured in passenger cars per hour). Reserve capacity is evaluated for all vehicles entering or crossing the major roadway traffic flow from side streets as well as those making left turns on the major roadway. The relationship between various levels of service and reserve capacity is as follows:

<u>Reserve Capacity</u>	<u>Level of Service</u>	<u>Expected Delay to Minor Street Traffic</u>
> 400	A	Little or no delay
300-399	B	Short traffic delays
200-299	C	Average traffic delays
100-199	D	Long traffic delays
0-99	E	Very long traffic delays
< 0	F	Extreme delays, usually warrants intersection improvement

Levels of service at four-way stop controlled intersections, such as N.E. 134th Street at N.E. 20th Avenue, cannot be precisely determined. However, the Highway Capacity Manual does provide guidelines to identify whether an intersection is operating better or worse than LOS "C". The variables used in this analysis include the layout of intersection lanes, total traffic volume approaching the intersection, and the directional demand split of traffic approaching the intersection.

The tables on the following pages summarize the results of level of service analysis for existing, 1998 and 2010 conditions without development of the WSU campus.

Table A-1

## Summary of Existing Levels of Service

## Stop Controlled Intersections

Intersection	Movement	AM Peak		PM Peak	
		Reserve Capacity	LOS	Reserve Capacity	LOS
134th St. @ I-5 SB on Ramp	SB(all)	78	E	101	D
	EBL	820	A	577	A
	WBL	227	C	468	A
134th St. @ I-5 NB off Ramp	NBL	58	E	-106 (1)	F
	NBR	859	A	173	D
	SBL	87	E	-85	F
	SBR	696	A	522	A
	EBL	431	A	641	A
134th St. @ I-205 SB on Ramp	WBL	925	A	978	A
134th St. @ I-205 NB off Ramp	NBL	430	A	164	D
	NBR	980	A	885	A
134th St. @ 29th Ave.	EBL	999	A	953	A
	SB(all)	707	A	617	A
134th St. @ Salmon Creek Ave.	EB(all)	740	A	671	A
	NBL	900	A	938	A
139th St. @ 20th Ave.	NBL	895	A	953	A
	SBL	996	A	776	A
	EB(all)	755	A	723	A
	WB(all)	406	A	303	B
139th St. @ 29th Ave.	NBL	975	A	998	A
	EB(all)	808	A	680	A
179th St. @ I-5 SB Ramp	SB(all)	-29	F	346	B
	WBL	7	E	614	A
179th St. @ I-5 NB on Ramp	EBL	431	A	602	A

## 4-Way Stop Controlled Intersections

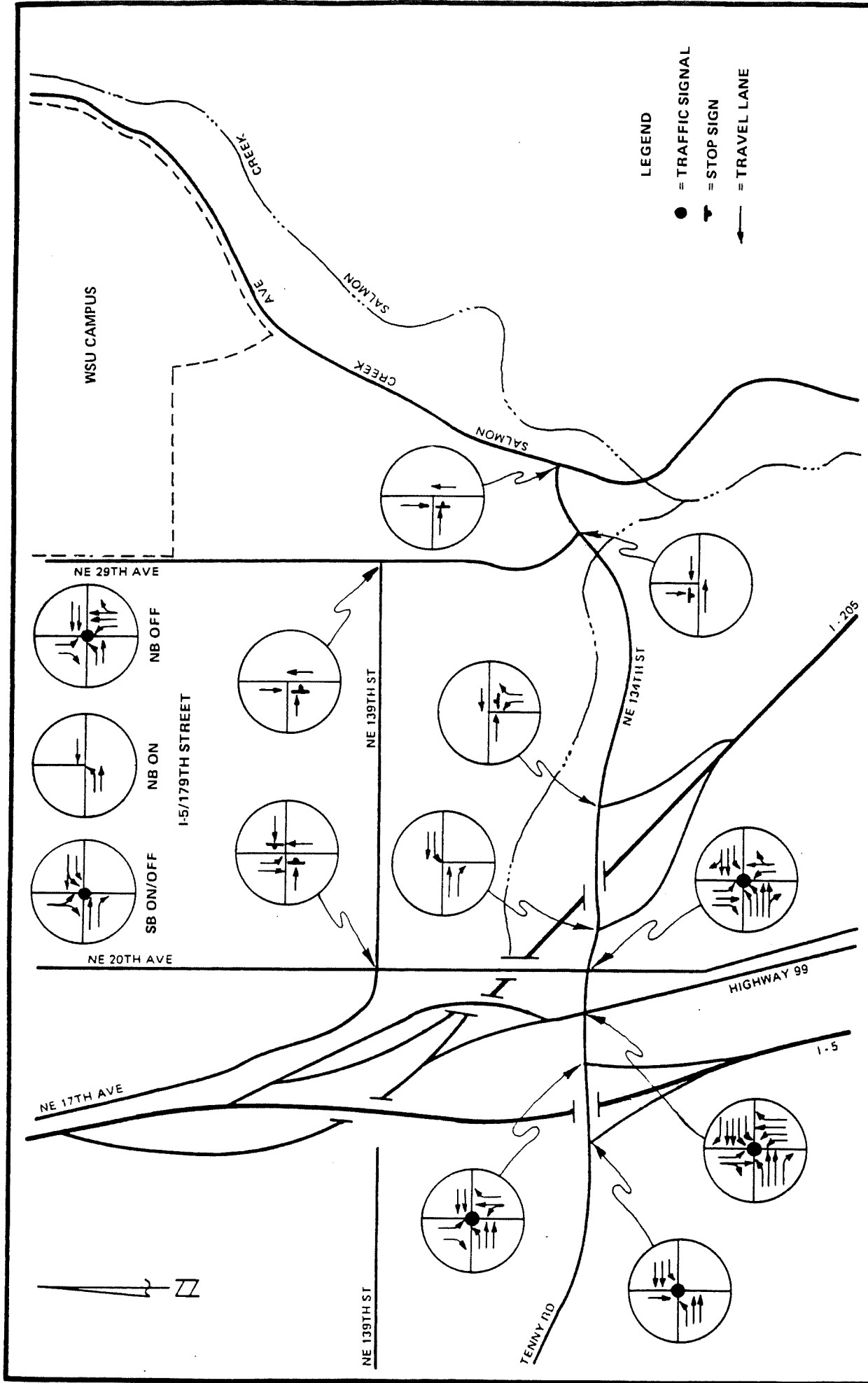
134th St. @ 20th Ave.	N/A	>C	N/A	>C
-----------------------	-----	----	-----	----

Table A-1 Continued

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Average Delay</u>	<u>LOS</u>
134th St. @ Hwy. 99 (1)	21.2	C	19.8	C
179th St. @ I-5 NB off Ramp	14.9	B	14.6	B

(1) Assumes 90 second average signal cycle length based on surveyed conditions during peak of the peak hour.



**ROADWAY SYSTEM ASSUMED FOR  
1998 LEVEL OF SERVICE ANALYSIS**

**FIGURE A-1**



Table A-2

Summary of 1998 Levels of Service  
Without Construction of WSU Campus

**Stop Controlled Intersections**

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Reserve Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	912	A	974	A
134th St. @ I-205 NB off Ramp	NBL	283	C	-30	F
	NBR	974	A	831	A
134th St. @ 29th Ave.	EBL	966	A	945	A
	SB(all)	613	A	649	A
134th St. @ Salmon Creek Ave.	NBL	849	A	908	A
	EB(all)	655	A	601	A
139th St. @ 20th Ave.	NBL	953	A	939	A
	SBL	776	A	713	A
	EB(all)	723	A	644	A
	WB(all)	303	B	234	C
139th St. @ 29th Ave.	NBL	998	A	998	A
	EB(all)	819	A	673	A
179th St. @ I-5 NB on Ramp	EBL	251	C	490	A

**Signalized Intersections**

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Average Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	12.3	B	7.2	B
134th St. @ I-5 NB off Ramp (1)	25.1	C/D	22.2	C
134th St. @ Hwy. 99 (1)	27.6	D	28.9	D
134th St. @ 20th Ave. (1)	25.6	D	27.7	D
179th St. @ I-5 SB Ramps (2)	15.3	B/C	16.9	C

Table A-2 Continued

**Signalized Intersections**

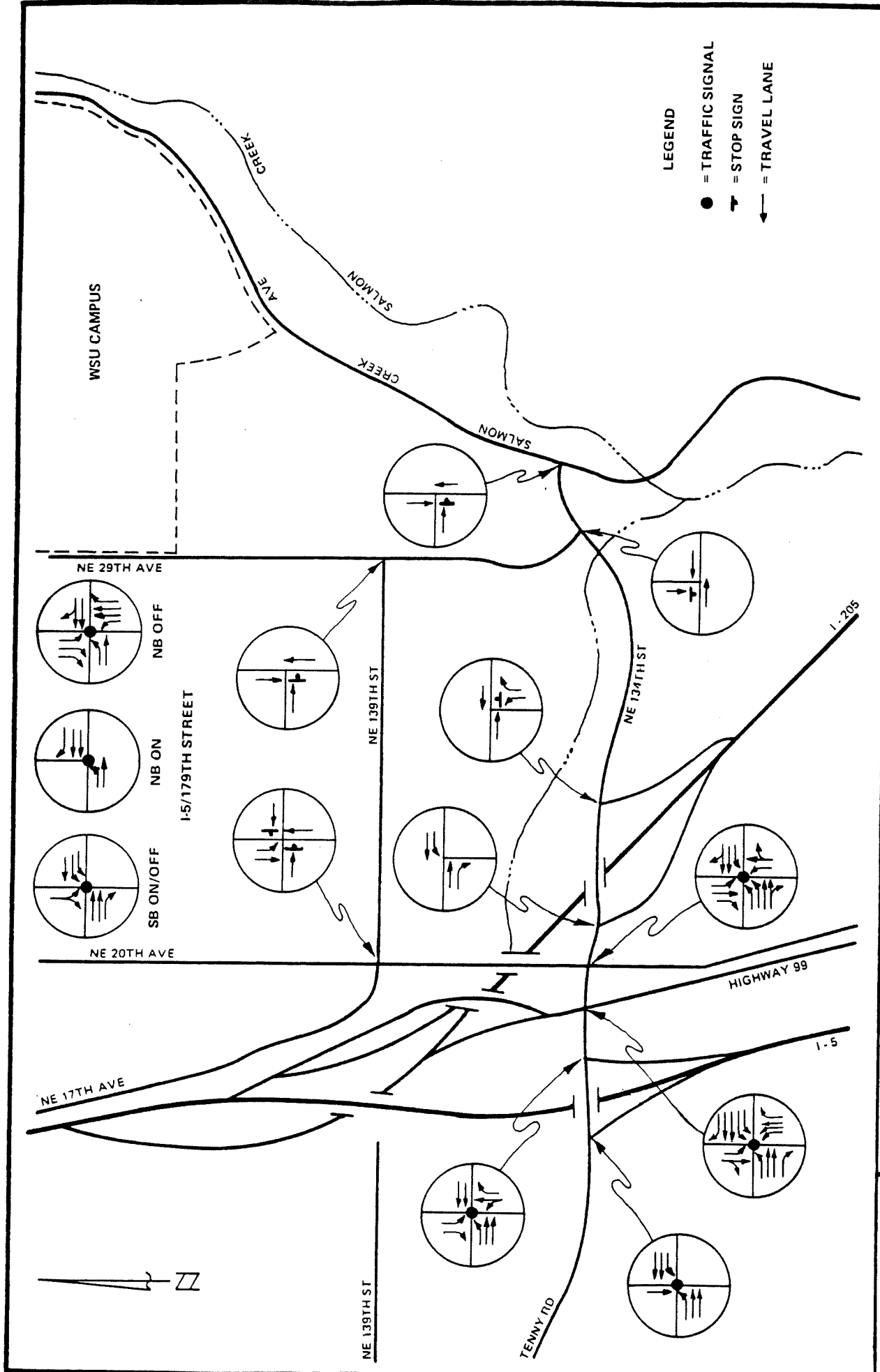
<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average</u> <u>Delay</u>	<u>LOS</u>	<u>Average</u> <u>Delay</u>	<u>LOS</u>
179th St. @ I-5 NB off Ramp (2)	25.8	D	18.1	C

-----

Note: All signal cycles are assumed to be 120 seconds in length.

(1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place (see Figure A-1).

(2) At N.E. 179th Street at I-5, proposed interim improvements are assumed to be in place (see Figure A-1).



**ROADWAY SYSTEM ASSUMED FOR  
2010 LEVEL OF SERVICE ANALYSIS**

**FIGURE A-2**

**Kimley-Horn**

Table A-3

Summary of 2010 Levels of Service  
Without Construction of WSU Campus

## Stop Controlled Intersections

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	851	A	920	A
134th St. @ I-205 NB off Ramp	NBL	24	E	-576	F
	NBR	954	A	668	A
134th St. @ 29th Ave.	EBL	874	A	846	A
	SB(all)	473	A	408	A
134th St. @ Salmon Creek Ave.	NBL	770	A	791	A
	EB(all)	482	A	338	B
139th St. @ 20th Ave.	NBL	989	A	842	A
	SBL	723	A	556	A
	EB(all)	540	A	398	B
	WB(all)	120	D	52	E
139th St. @ 29th Ave.	NBL	925	A	994	A
	EB(all)	735	A	514	A

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	26.7	D	9.5	B
134th St. @ I-5 NB off Ramp (1)	20.4	C	53.2	E
134th St. @ Hwy. 99 (1)	31.5	D	61.3	F
134th St. @ 20th Ave. (1)	27.1	D	36.4	D
179th St. @ I-5 SB Ramps (2)	22.2	C	22.0	C
179th St. @ I-5 NB on Ramp (2)	2.8	A	2.6	A

Table A-3 Continued

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
179th St. @ I-5 NB off Ramp (2)	21.9	C	23.3	C

-----  
 Note: All signal cycles are assumed to be 120 seconds in length.

- (1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.
- (2) At N.E. 179th Street at I-5, ultimate improvements are assumed to be in place. These include provision of additional travel lanes under I-5 on N.E. 179th Street and a northbound right turn only lane at the northbound I-5 off ramp (see Figure A-2).

Appendix B

Mitigation of Traffic Impacts  
for 2010 Conditions Without  
Development of WSU Campus

## APPENDIX B

Table B-1

Mitigation of 2010 Traffic Congestion Problems  
for Conditions Without Development of WSU Campus

### Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 NB off Ramp (1)	19.6	C	27.8	D
134th St. @ Hwy. 99 (2)	27.2	D	36.0	D
134th St. @ I-205 NB off Ramp (3)	14.4	B	13.8	B

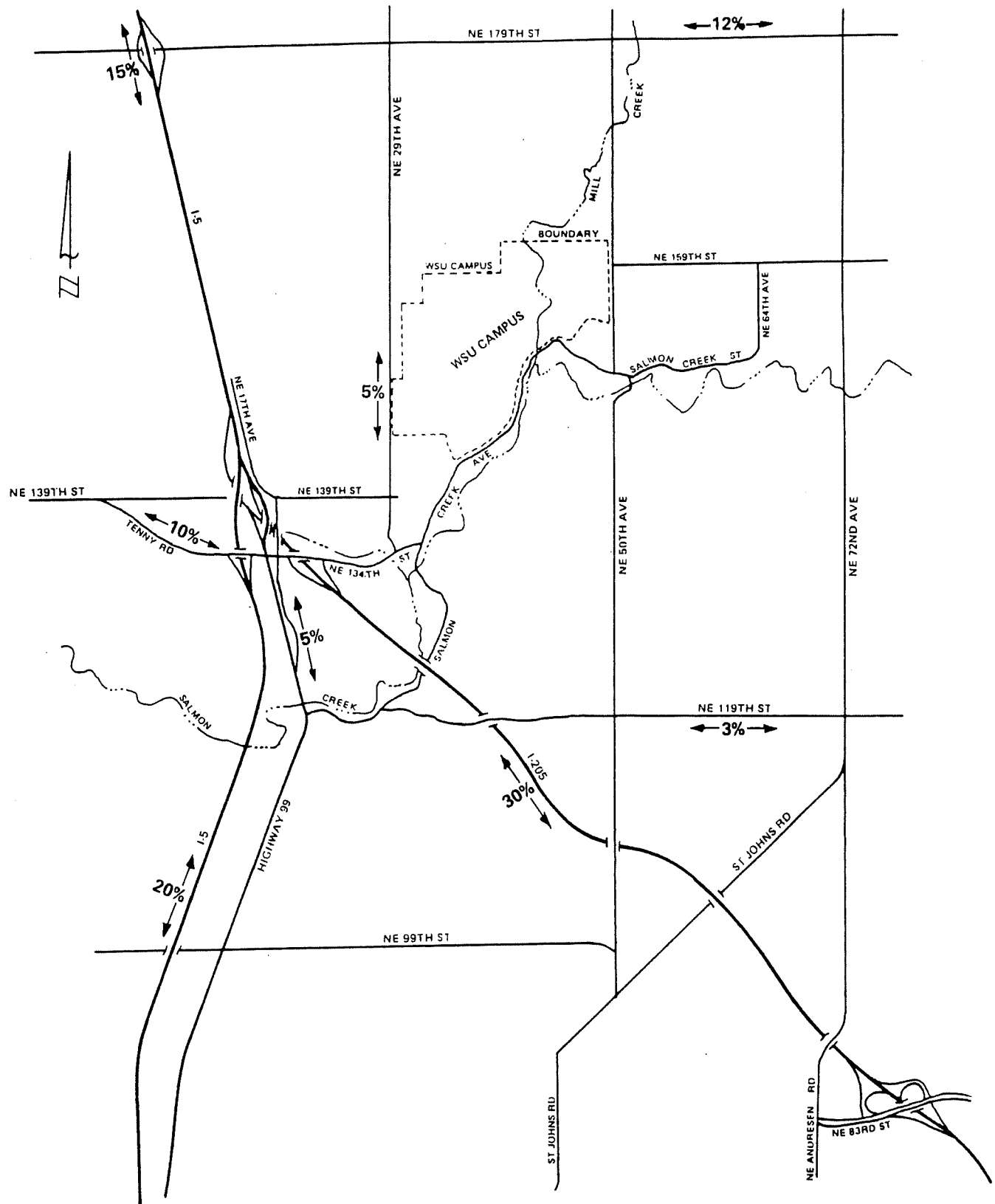
- (1) Includes addition of second northbound right turn lane.  
 (2) Includes addition of southbound right turn lane.  
 (3) Includes installation of traffic signal and a second northbound left turn lane at this intersection.

## Appendix C

### Trip Distribution Assumptions





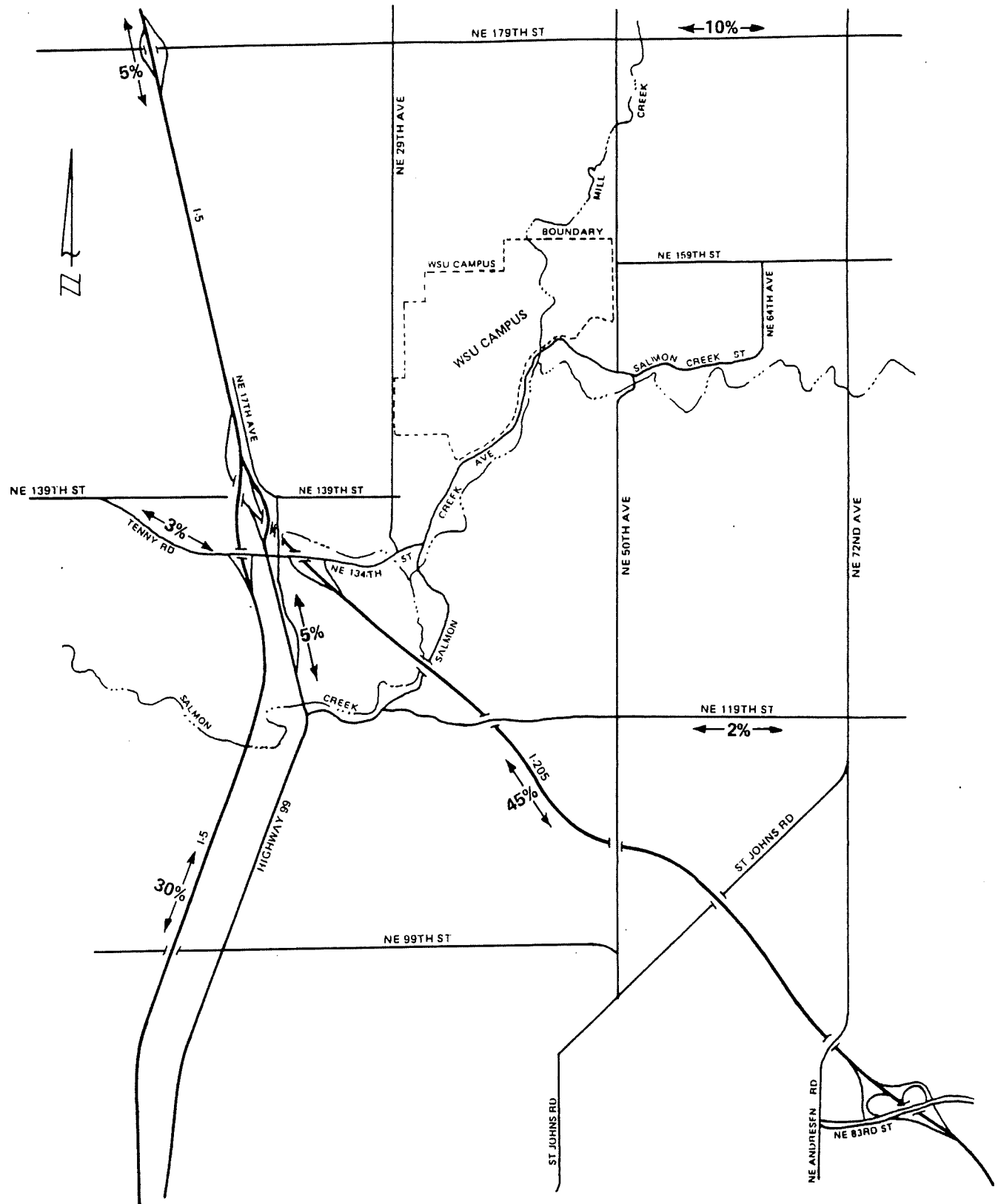


**FIGURE C-2**

**2010 TRIP DISTRIBUTION ASSUMPTIONS  
FOR WSU CAMPUS**

**Kimley-Horn**

Kimley-Horn and Associates, Inc.



**Kimley-Horn**

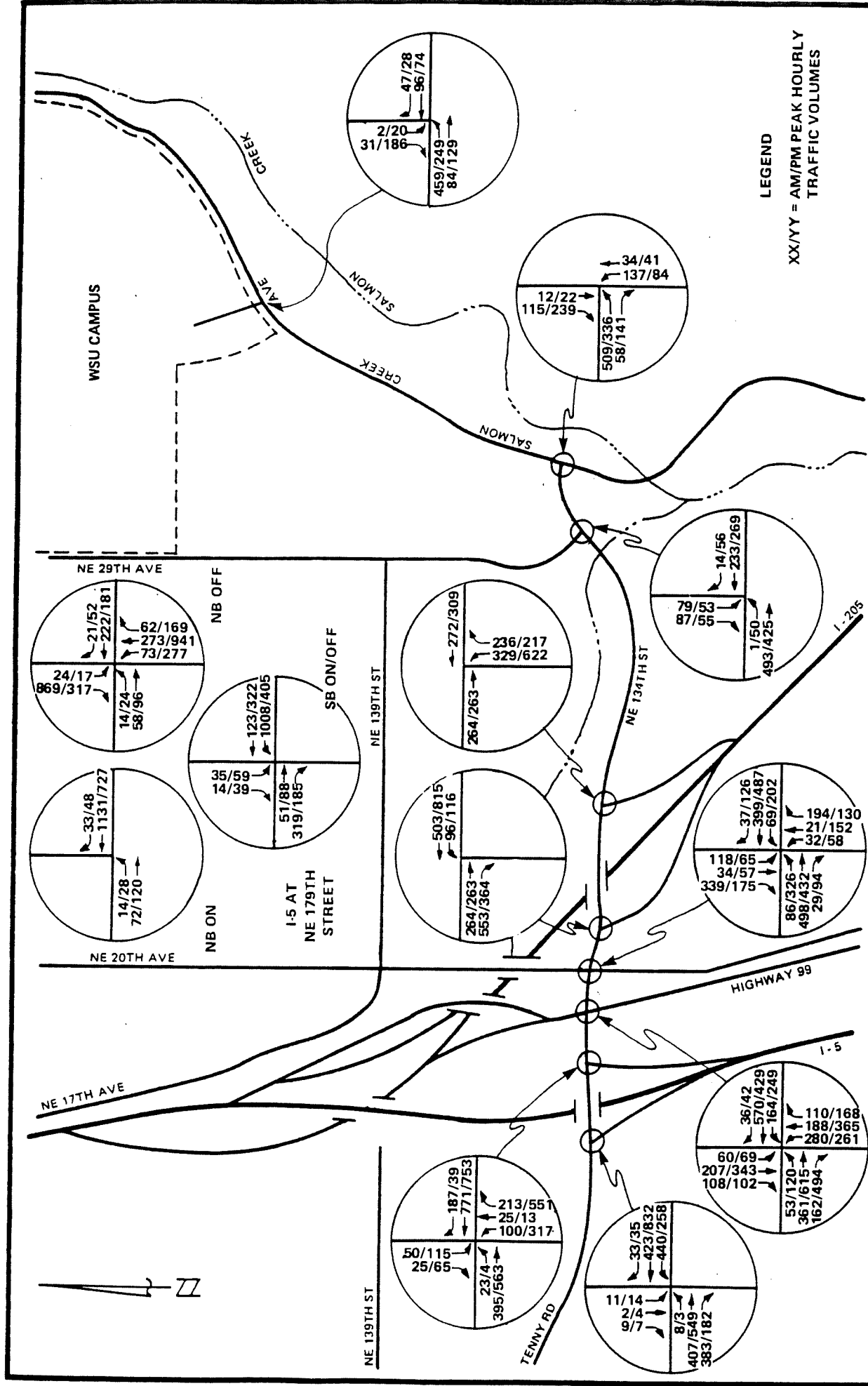
Kimley-Horn and Associates, Inc.

### FIGURE C-3

TRIP DISTRIBUTION ASSUMPTIONS FOR  
USGS, AG. RESEARCH AND CONTRACT  
RESEARCH FACILITIES ON WSU CAMPUS

## Appendix D

1998 and 2010 Traffic Volumes  
and Levels of Service with  
Salmon Creek Avenue Access  
Alternative



**1998 PEAK HOUR TRAFFIC VOLUMES WITH WSU  
SALMON CREEK AVENUE ACCESS ALTERNATIVE**

**Kimley-Horn**

**FIGURE D-1**

Table D-1

Summary of 1998 Levels of Service  
With Construction of WSU Campus  
Salmon Creek Avenue Access Alternative

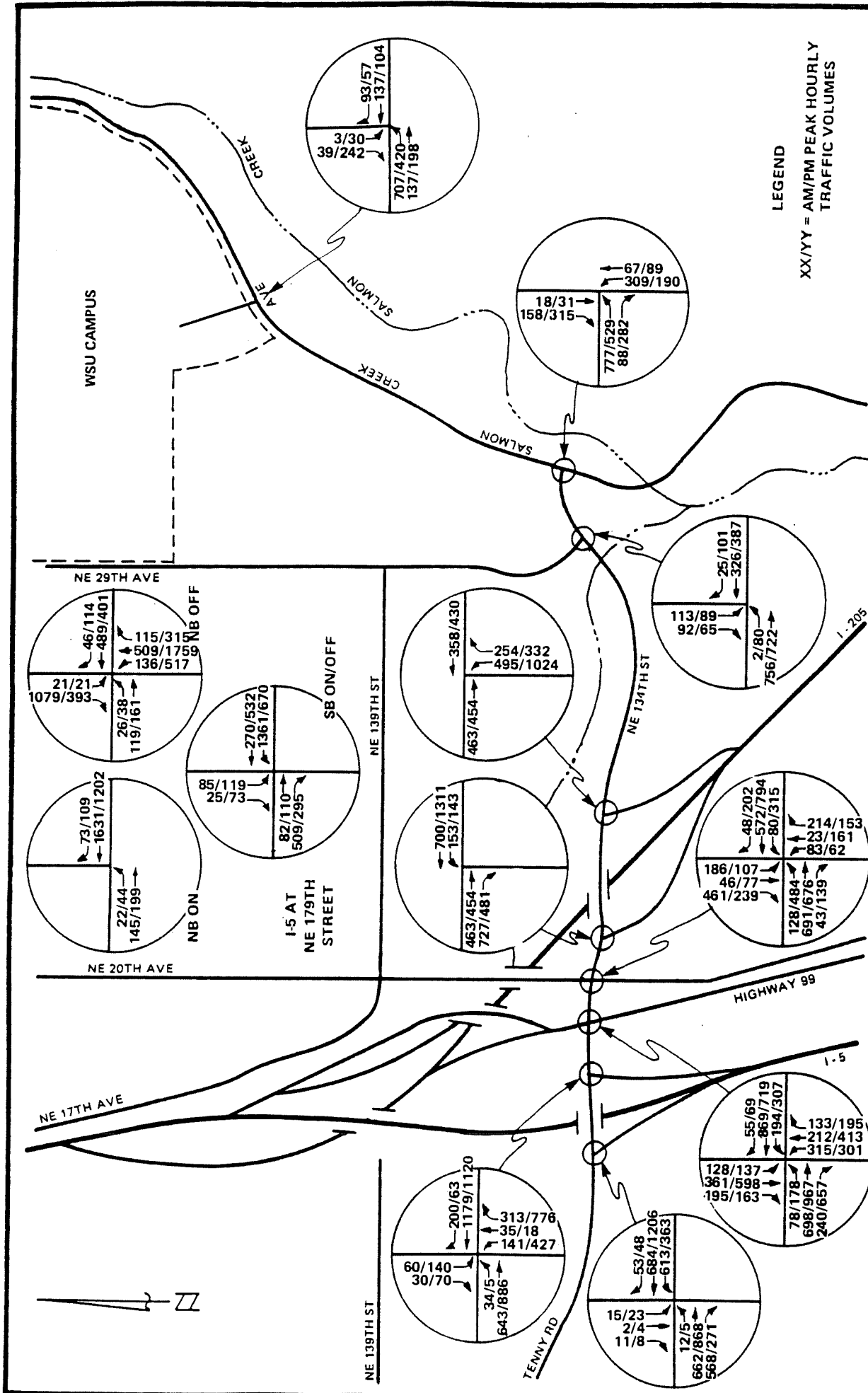
## Stop Controlled Intersections

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Reserve Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	813	A	792	A
134th St. @ I-205 NB off Ramp	NBL	103	D	-244	F
	NBR	563	A	585	A
134th St. @ 29th Ave.	EBL	934	A	809	A
	SB(all)	319	B	333	B
134th St. @ Salmon Creek Ave.	NBL	849	A	831	A
	EB(all)	16	E	166	D
179th St. @ I-5 NB on Ramp	EBL	251	C	409	A
Salmon Creek Ave. @ WSU Access	NBL	495	A	726	A
	EBL	221	C	384	B
	EBR	940	A	795	A

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Average Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	15.7	C	8.9	B
134th St. @ I-5 NB off Ramp (1)	16.8	C	23.2	C
134th St. @ Hwy. 99 (1)	27.6	D	30.0	D
134th St. @ 20th Ave. (1)	26.4	D	28.3	D
179th St. @ I-5 SB Ramps (2)	15.9	C	17.1	C
179th St. @ I-5 NB off Ramp (2)	25.8	D	18.1	C

Note: All signal cycles are assumed to be 120 seconds in length.  
 (1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.  
 (2) At N.E. 179th Street at I-5, proposed interim improvements are assumed to be in place.



**2010 PEAK HOUR TRAFFIC VOLUMES WITH WSU  
SALMON CREEK AVENUE ACCESS ALTERNATIVE**

**Kimley-Horn**

Table D-2

Summary of 2010 Levels of Service  
With Construction of WSU Campus  
Salmon Creek Avenue Access Alternative

**Stop Controlled Intersections**

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	675	A	694	A
134th St. @ I-205 NB off Ramp	NBL	-194	F	-804	F
	NBR	464	A	386	B
134th St. @ 29th Ave.	EBL	913	A	733	A
	SB(all)	124	D	92	E
134th St. @ Salmon Creek Ave.	NBL	660	A	745	A
	EB(all)	-510	F	-305	F
Salmon Creek Ave. @ WSU Access	NBL	222	C	538	A
	EBL	71	E	203	C
	EBR	954	A	734	A

**Signalized Intersections**

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	28.2	D	12.0	B
134th St. @ I-5 NB off Ramp (1)	22.8	C	56.8	E
134th St. @ Hwy. 99 (1)	34.0	D	77.2	F
134th St. @ 20th Ave. (1)	30.6	D	37.7	D
179th St. @ I-5 SB Ramps (2)	24.3	C	23.0	C
179th St. @ I-5 NB on Ramp (2)	2.8	A	2.9	A
179th St. @ I-5 NB off Ramp (2)	22.0	C	23.6	C

-----  
 Note: All signal cycles are assumed to be 120 seconds in length.  
 (1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.  
 (2) Ultimate improvements assumed to be in place at this intersection. These include provision of additional travel lanes under I-5 on N.E. 179th Street, signalization at the northbound on-ramp and a northbound right turn only lane at the northbound I-5 off ramp.



Appendix E

Mitigation of Traffic Impacts  
with Salmon Creek Avenue Access  
Alternative

Table E-1

Summary of 1998 Levels of Service with Mitigation  
For Construction of WSU Campus  
Salmon Creek Avenue Access Alternative

## 3-Way Stop Controlled Intersection

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Capacity</u>	<u>LOS</u>
134th St. @ Salmon Creek Ave.		N/A	>C	N/A	>C

## Signalized Intersection

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-205 NB off Ramp (1)	14.6	B	17.4	C

(1) Install traffic signal.

Table E-2

Summary of 2010 Levels of Service with Mitigation  
For Construction of WSU Campus  
Salmon Creek Avenue Access Alternative

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 NB off Ramp (1)	21.1	C	35.9	D
134th St. @ Hwy. 99 (2)	30.1	D	33.6	D
134th St. @ I-205 NB off Ramp (3)	17.2	C	20.8	C
134th St. @ 29th Avenue (4)	10.4	B	8.3	B
134th St. @ Salmon Creek Avenue (5)	19.1	C	19.9	C

- (1) Includes addition of second northbound right turn lane (improvement to be made to accommodate 2010 background traffic volumes without WSU).
- (2) Add second southbound through lane and eliminate free eastbound right.
- (3) Install traffic signal and second northbound left turn lane. (Traffic signal to be added in 1998. Turn lane to be added to accommodate 2010 background traffic volumes without WSU).
- (4) Install traffic signal and eastbound left turn lane.
- (5) Install traffic signal.

Appendix F

1998 and 2010 Traffic Volumes  
and Levels of Service with  
N.E. 29th Avenue Access  
Alternative

**FIGURE F-1**

**1998 PEAK HOUR TRAFFIC VOLUMES WITH WSU  
N.E. 29TH AVENUE ACCESS ALTERNATIVE**

**Kimley-Horn**

**LEGEND**  
XX/YY = AM/PM PEAK HOURLY  
TRAFFIC VOLUMES

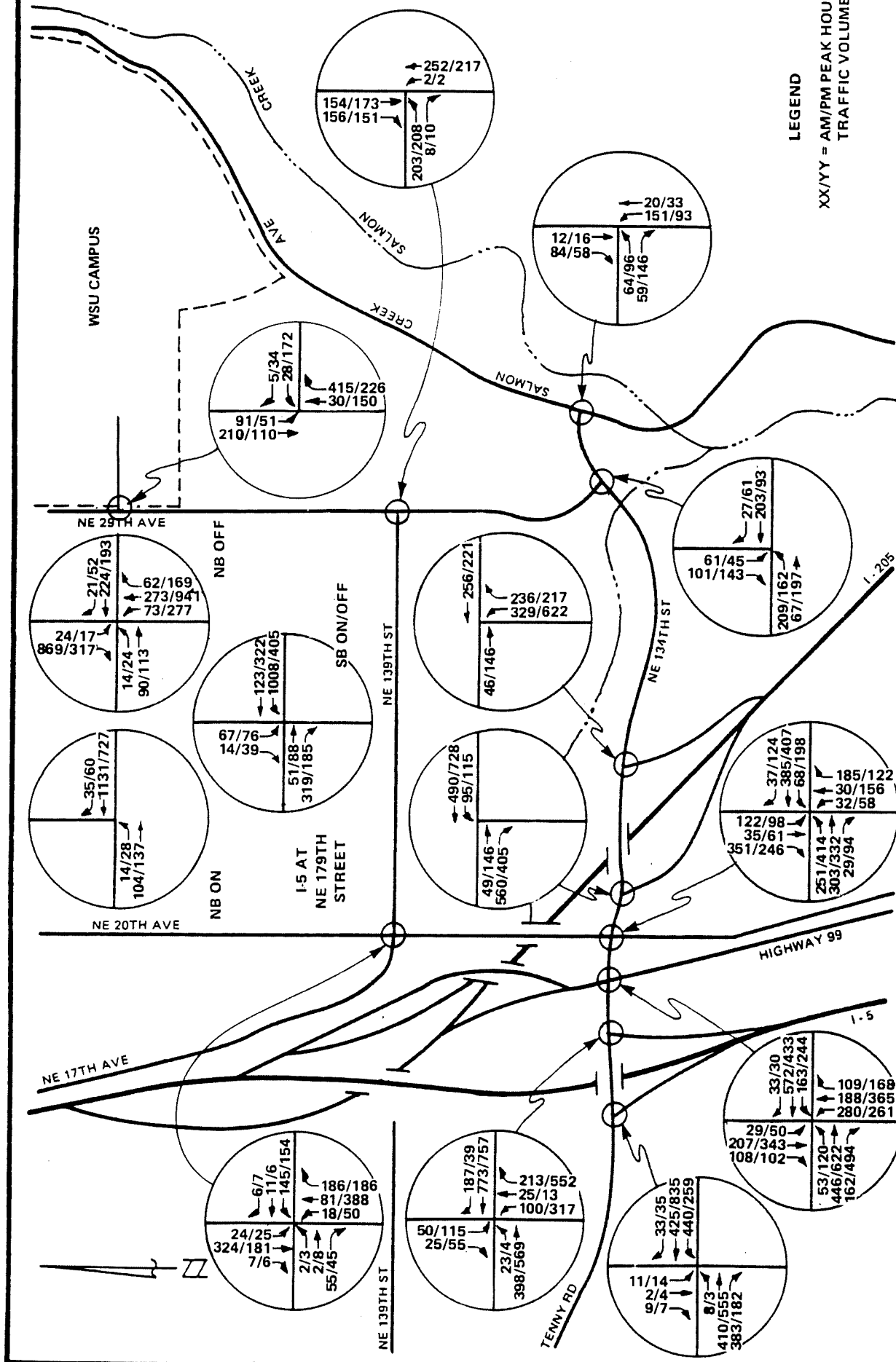


Table F-1

Summary of 1998 Levels of Service  
With Construction of WSU Campus  
N.E. 29th Avenue Access Alternative

## Stop Controlled Intersections

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Reserve Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	895	A	873	A
134th St. @ I-205 NB off Ramp	NBL	267	C	-101	F
	NBR	741	A	708	A
134th St. @ 29th Ave.	EBL	722	A	822	A
	SB(all)	433	A	546	A
134th St. @ Salmon Creek Ave.	NBL	834	A	899	A
	EB(all)	624	A	590	A
139th St. @ 20th Ave.	NBL	839	A	939	A
	SBL	903	A	623	A
	EB(all)	659	A	598	A
	WB(all)	226	C	105	D
139th St. @ 29th Ave.	NBL	875	A	863	A
	EB(all)	292	C	281	C
179th St. @ I-5 NB on Ramp	EBL	251	C	405	A
N.E. 29th Avenue @ WSU Access	SBL	660	A	764	A
	WBL	390	B	332	B
	WBR	844	A	787	A

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Average Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	15.7	C	8.9	B
134th St. @ I-5 NB off Ramp (1)	16.8	C	23.2	C
134th St. @ Hwy. 99 (1)	27.7	D	30.8	D
134th St. @ 20th Ave. (1)	26.9	D	29.1	D

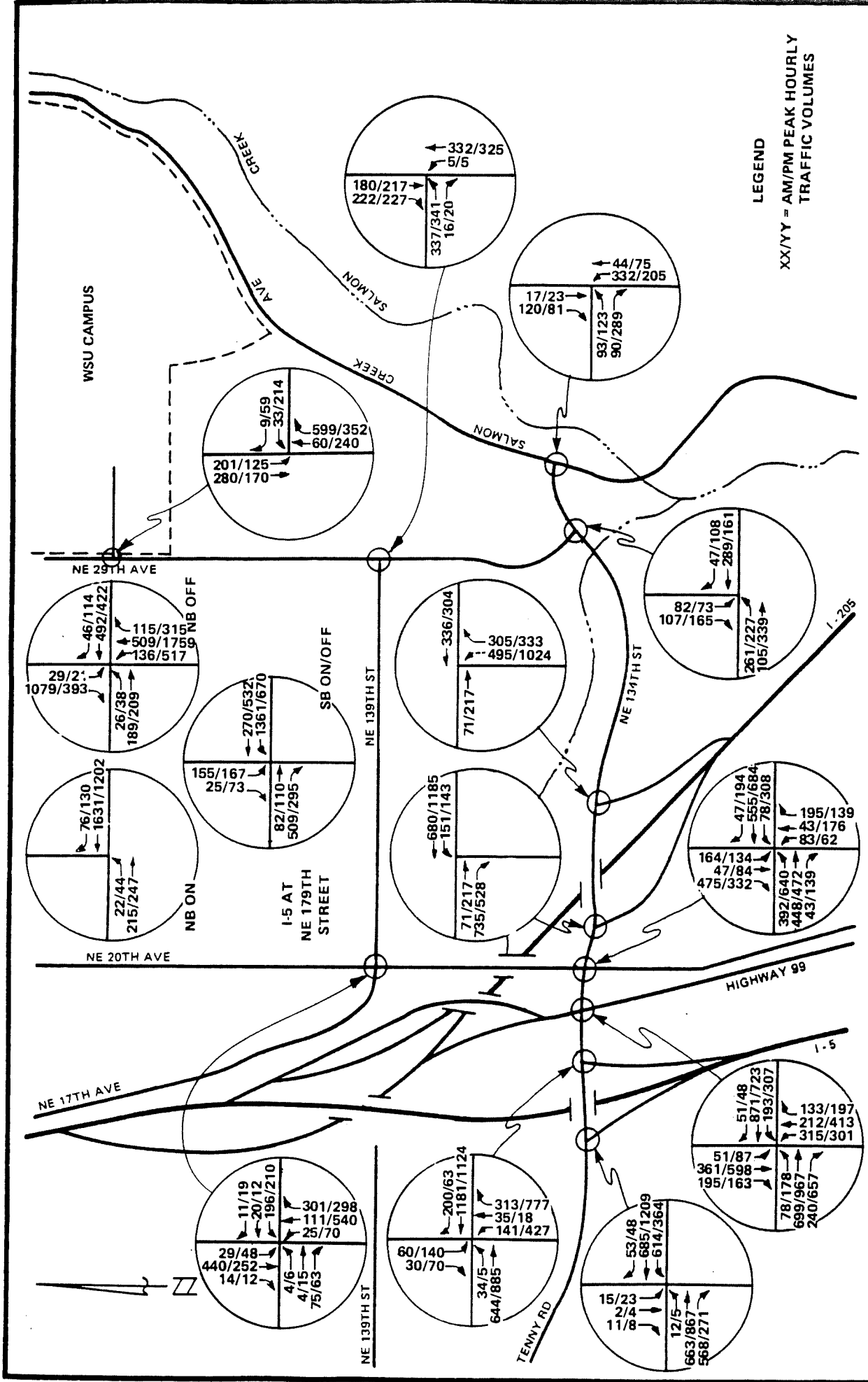
Table F-1 Continued

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Average Delay</u>	<u>LOS</u>
179th St. @ I-5 SB Ramps (2)	17.9	C	17.9	C
179th St. @ I-5 NB off Ramp (2)	26.0	D	18.3	C

Note: All signal cycles are assumed to be 120 seconds in length.

- (1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.
- (2) At N.E. 179th Street at I-5, proposed interim improvements are assumed to be in place.



**2010 PEAK HOUR TRAFFIC VOLUMES WITH WSU  
N.E. 29TH AVENUE ACCESS ALTERNATIVE**

**Kimley-Horn**

**FIGURE F-2**



Table F-2

Summary of 2010 Levels of Service  
With Construction of WSU Campus  
N.E. 29th Avenue Access Alternative

**Stop Controlled Intersections**

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	834	A	843	A
134th St. @ I-205 NB off Ramp	NBL	75	E	-591	F
	NBR	664	A	598	A
134th St. @ 29th Ave.	EBL	677	A	750	A
	SB(all)	304	B	317	B
134th St. @ Salmon Creek Ave.	NBL	635	A	776	A
	EB(all)	382	B	359	B
139th St. @ 20th Ave.	NBL	823	A	923	A
	SBL	963	A	509	A
	EB(all)	600	A	486	A
	WB(all)	112	D	-62	F
139th St. @ 29th Ave.	NBL	892	A	854	A
	EB(all)	84	E	-3	F
N.E. 29th Ave. @ WSU Access	SBL	376	B	594	A
	WBL	179	D	99	E
	WBR	765	A	721	A

**Signalized Intersections**

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	28.3	D	12.1	B
134th St. @ I-5 NB off Ramp (1)	22.8	C	54.9	E
134th St. @ Hwy. 99 (1)	33.6	D	73.4	F
134th St. @ 20th Ave. (1)	33.3	D	38.3	D
179th St. @ I-5 SB Ramps (2)	31.2	D	25.7	D

Table F-2 Continued

**Signalized Intersections**

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average</u> <u>Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
179th St. @ I-5 NB on Ramp (2)	2.7	A	2.5	A
179th St. @ I-5 NB off Ramp (2)	22.6	C	24.3	C

-----  
 Note: All signal cycles are assumed to be 120 seconds in length.

- (1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.
- (2) Ultimate improvements assumed to be in place at this intersection. These include provision of additional travel lanes under I-5 on N.E. 179th Street, signalization at the northbound on-ramp and a northbound right turn only lane at the northbound I-5 off ramp.

## Appendix G

Mitigation of Traffic Impacts  
with N.E. 29th Avenue Access  
Alternative

Table G-1

Summary of 1998 Levels of Service with Mitigation  
For Construction of WSU Campus  
N.E. 29th Avenue Access Alternative

Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average</u> <u>Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-205 NB off Ramp (1)	13.1	B	13.4	B

(1) Install traffic signal.

Table G-2

Summary of 2010 Levels of Service with Mitigation  
For Construction of WSU Campus  
N.E. 29th Avenue Access Alternative

**3-Way Stop Controlled Intersections**

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Capacity</u>	<u>LOS</u>
139th St. @ 29th Ave. (1)		N/A	>C	N/A	>C
29th Ave. @ WSU Access (2)		N/A	>C	N/A	>C

**Signalized Intersections**

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 NB off Ramp (3)	21.1	C	38.2	D
134th St. @ Hwy. 99 (4)	26.8	D	33.6	D
134th St. @ I-205 NB off Ramp (5)	13.4	B	14.3	B
139th St. @ 20th Ave. (6)	17.2	C	31.1	D

- (1) Install 3-way stop with northbound left and southbound right turn lanes (intersection does not meet traffic signal warrants).
- (2) Install 3-way stop with northbound right and southbound left turn lanes (intersection does not meet traffic signal warrants).
- (3) Includes addition of second northbound right turn lane (improvement to be made to accommodate 2010 background traffic volumes without WSU).
- (4) Add second southbound through lane and eliminate free east-bound right.
- (5) Install traffic signal and second northbound left turn lane. (Traffic signal to be added in 1998. Turn lane to be added to accommodate 2010 background traffic volumes without WSU).
- (6) Install traffic signal with north and southbound left turn lanes.

Appendix H

1998 and 2010 Traffic Volumes  
and Levels of Service with  
N.E. 179th Street Access  
Alternative



Table H-1

Summary of 1998 Levels of Service  
With Construction of WSU Campus  
N.E. 179th Street Access Alternative

## Stop Controlled Intersections

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Reserve Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	912	A	974	A
134th St. @ I-205 NB off Ramp	NBL	249	C	-62	F
	NBR	974	A	808	A
134th St. @ 29th Ave.	EBL	922	A	921	A
	SB(all)	580	A	601	A
134th St. @ Salmon Creek Ave.	NBL	849	A	908	A
	EB(all)	655	A	664	A
179th St. @ I-5 NB on Ramp	EBL	243	C	326	B
179th St. @ WSU Access	NBL	629	A	473	A
	NBR	994	A	972	A
	WBL	933	A	964	A

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Average Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	15.6	C	8.2	B
134th St. @ I-5 NB off Ramp (1)	15.5	C	22.2	C
134th St. @ Hwy. 99 (1)	27.6	D	29.2	D
134th St. @ 20th Ave. (1)	25.6	D	28.1	D
179th St. @ I-5 SB Ramps (2)	17.9	C	17.7	C
179th St. @ I-5 NB off Ramp (2)	26.0	D	19.6	C

Note: All signal cycles are assumed to be 120 seconds in length.  
 (1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.  
 (2) At N.E. 179th Street at I-5, proposed interim improvements are assumed to be in place.



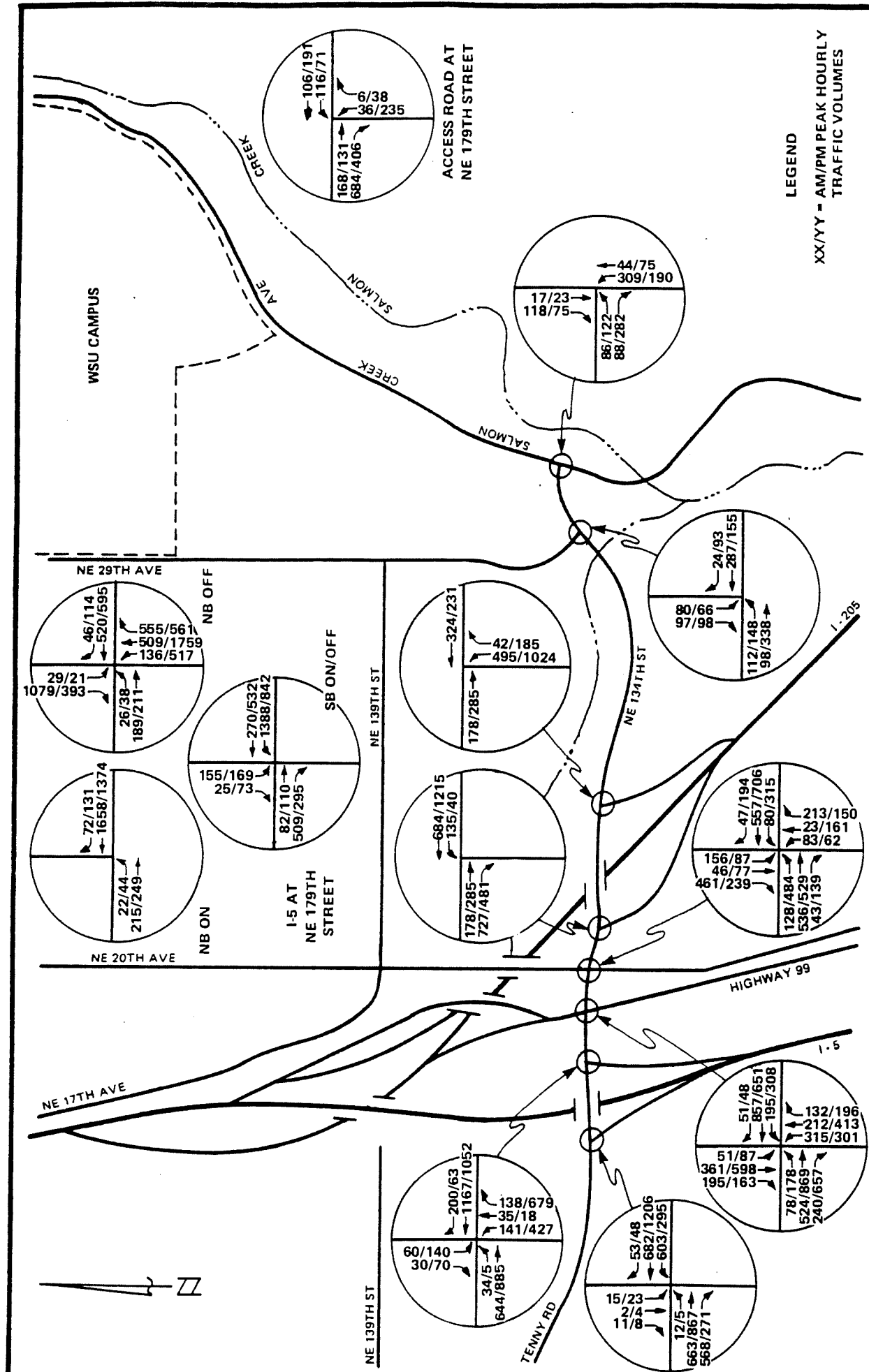


Table H-2

Summary of 2010 Levels of Service  
With Construction of WSU Campus  
N.E. 179th Street Access Alternative

## Stop Controlled Intersections

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	851	A	956	A
134th St. @ I-205 NB off Ramp	NBL	4	E	-587	F
	NBR	954	A	695	A
134th St. @ 29th Ave.	EBL	866	A	837	A
	SB(all)	462	A	413	A
134th St. @ Salmon Creek Ave.	NBL	660	A	791	A
	EB(all)	422	A	377	B
179th St. @ WSU Access	NBL	542	A	340	B
	NBR	993	A	958	A
	WBL	872	A	922	A

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	28.1	D	9.6	B
134th St. @ I-5 NB off Ramp (1)	20.3	C	54.1	E
134th St. @ Hwy. 99 (1)	31.7	D	63.9	F
134th St. @ 20th Ave. (1)	30.4	D	36.6	D
179th St. @ I-5 SB Ramps (2)	32.4	D	26.1	D
179th St. @ I-5 NB on Ramp (2)	2.7	A	2.6	A
179th St. @ I-5 NB off Ramp (2)	22.4	C	34.6	D

-----  
 Note: All signal cycles are assumed to be 120 seconds in length.  
 (1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.  
 (2) Ultimate improvements assumed to be in place at this intersection. These include provision of additional travel lanes under I-5 on N.E. 179th Street, signalization at the northbound on-ramp and a northbound right turn only lane at the northbound I-5 off ramp.

Appendix I

Mitigation of Traffic Impacts  
with N.E. 179th Street Access  
Alternative

Table I-1

Summary of 2010 Levels of Service with Mitigation  
For Construction of WSU Campus  
N.E. 179th Street Access Alternative

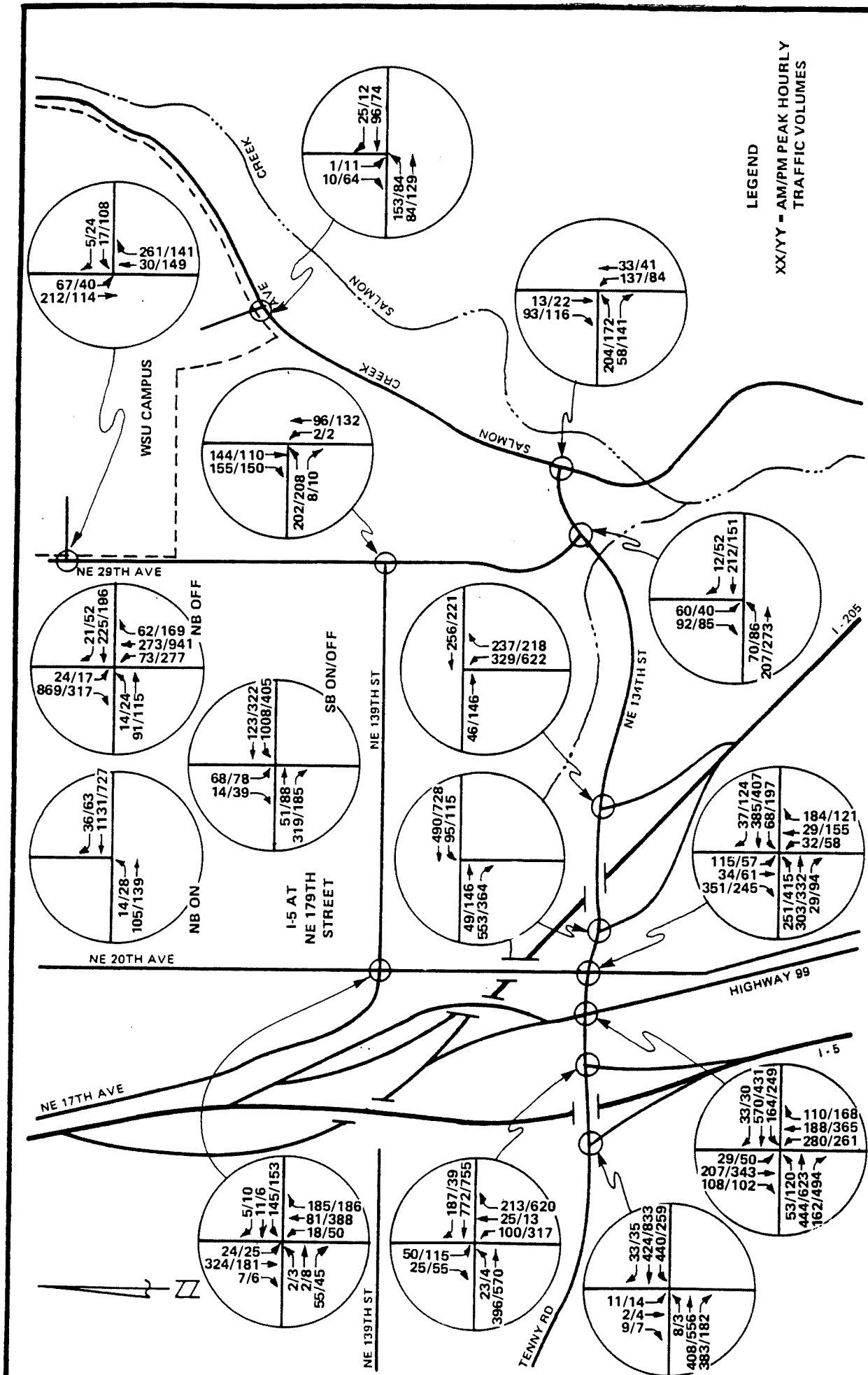
**Signalized Intersections**

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 NB off Ramp (1)	20.2	C	29.6	D
134th St. @ Hwy. 99 (2)	28.1	D	37.9	D
134th St. @ I-205 NB off Ramp (3)	14.8	B	14.1	B

- (1) Includes addition of second northbound right turn lane (improvement to be made to accommodate 2010 background traffic volumes without WSU).
- (2) Add second southbound through lane and eliminate free east-bound right.
- (3) Install traffic signal and second northbound left turn lane. (Traffic signal to be added in 1998. Turn lane to be added to accommodate 2010 background traffic volumes without WSU).

Appendix J

1998 and 2010 Traffic Volumes  
and Levels of Service with  
Access Via Both Salmon Creek  
and N.E. 29th Avenue



**1998 PEAK HOUR TRAFFIC VOLUMES WITH WSU**  
**N.E. 29TH AND SALMON CREEK AVENUE ACCESS ALTERNATIVE**

**Kimley-Horn**

**FIGURE J-1**

Table J-1

Summary of 1998 Levels of Service  
With Construction of WSU Campus  
Access Via Both N.E. 29th Avenue  
and Salmon Creek Avenue

## Stop Controlled Intersections

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Reserve Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	895	A	873	A
134th St. @ I-205 NB off Ramp	NBL	267	C	-101	F
	NBR	739	A	707	A
134th St. @ 29th Ave.	EBL	879	A	882	A
	SB(all)	483	A	540	A
134th St. @ Salmon Creek Ave.	NBL	849	A	908	A
	EB(all)	393	B	445	A
179th St. @ I-5 NB on Ramp	EBL	250	C	408	B
139th St. @ 20th Ave.	NBL	838	A	939	A
	SBL	891	A	623	A
	EB(all)	657	A	597	A
	WB(all)	220	C	105	D
139th St. @ 29th Ave.	NBL	884	A	921	A
	EB(all)	392	B	386	B
Salmon Creek Ave. @ WSU Access	NBL	832	A	908	A
	EBL	531	A	586	A
	EBR	975	A	930	A
29th Ave. @ WSU Access	SBL	829	A	851	A
	WBL	493	A	442	A
	WBR	935	A	843	A

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Average Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	15.7	C	8.9	B
134th St. @ I-5 NB off Ramp (1)	16.8	C	24.0	C

Table J-1 Continued

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Average Delay</u>	<u>LOS</u>
134th St. @ Hwy. 99 (1)	27.7	D	29.8	D
134th St. @ 20th Ave. (1)	27.0	D	28.5	D
179th St. @ I-5 SB Ramps (2)	17.6	C	17.9	C
179th St. @ I-5 NB off Ramp (2)	26.0	D	18.3	C

Note: All signal cycles are assumed to be 120 seconds in length.

- (1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.
- (2) At N.E. 179th Street at I-5, proposed interim improvements are assumed to be in place.



FIGURE J-2

2010 PEAK HOUR TRAFFIC VOLUMES WITH WSU  
N.E. 29TH AND SALMON CREEK AVENUE ACCESS ALTERNATIVE

Kimley-Horn

LEGEND  
XX/YY = AM/PM PEAK HOURLY  
TRAFFIC VOLUMES

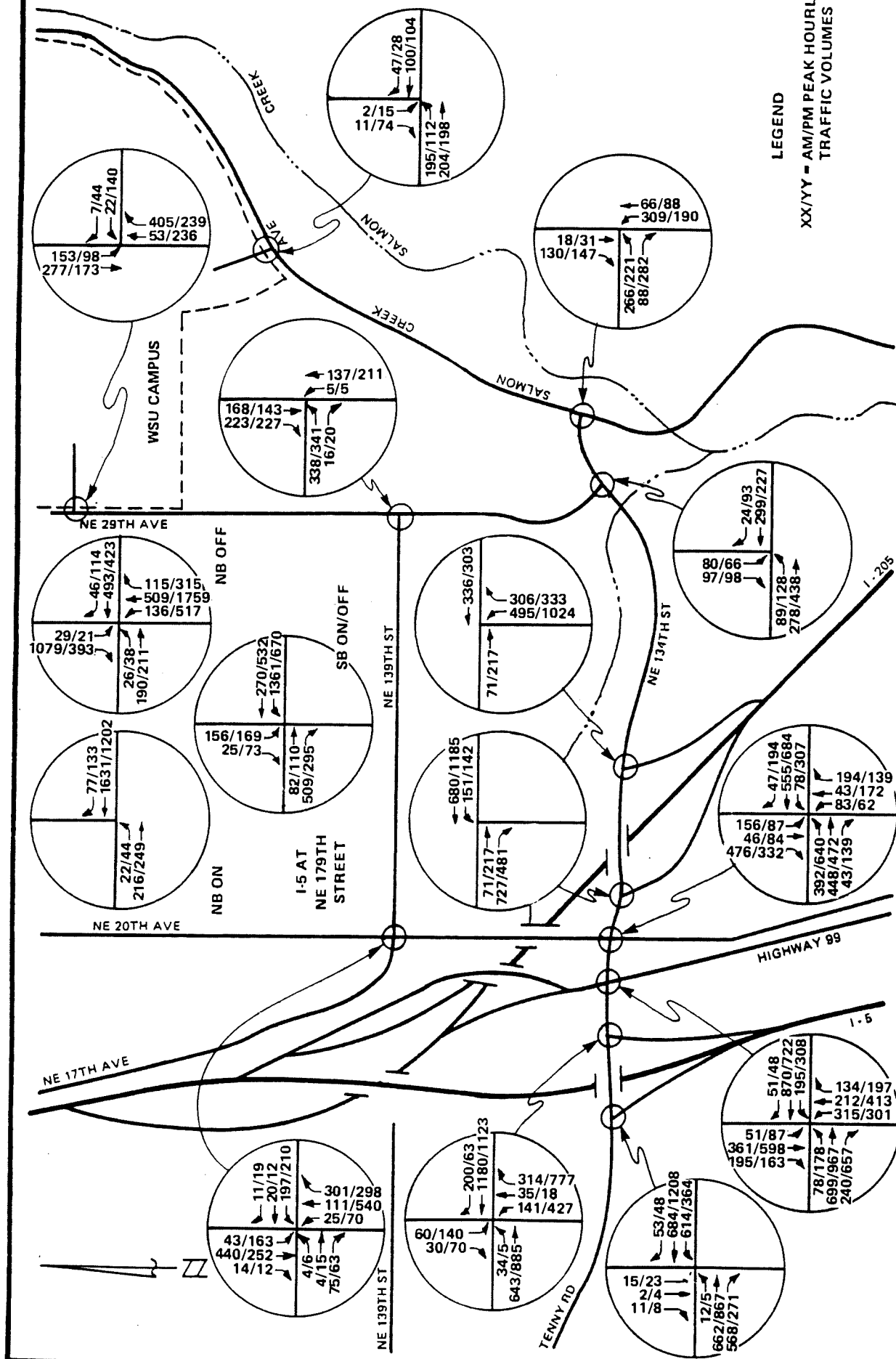


Table J-2

Summary of 2010 Levels of Service  
With Construction of WSU Campus  
Access Via Both N.E. 29th Avenue  
and Salmon Creek Avenue

**Stop Controlled Intersections**

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	834	A	844	A
134th St. @ I-205 NB off Ramp	NBL	75	E	-590	F
	NBR	663	A	598	A
134th St. @ 29th Ave.	EBL	879	A	839	A
	SB(all)	378	B	328	B
134th St. @ Salmon Creek Ave.	NBL	660	A	791	A
	EB(all)	106	D	177	D
139th St. @ 20th Ave.	NBL	823	A	923	A
	SBL	842	A	383	B
	EB(all)	578	A	277	C
	WB(all)	58	E	-134	F
139th St. @ 29th Ave.	NBL	903	A	924	A
	EB(all)	228	C	190	D
Salmon Creek Ave. @ WSU Access	NBL	785	A	877	A
	EBL	452	A	539	A
	EBR	988	A	919	A
29th Ave. @ WSU Access	SBL	680	A	725	A
	WBL	341	B	271	C
	WBR	919	A	789	A

**Signalized Intersections**

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	28.2	D	12.0	B
134th St. @ I-5 NB off Ramp (1)	22.9	C	56.9	E
134th St. @ Hwy. 99 (1)	33.6	D	73.4	F
134th St. @ 20th Ave. (1)	30.3	D	37.4	D

Table J-2 Continued

**Signalized Intersections**

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
179th St. @ I-5 SB Ramps (2)	33.5	D	25.9	D
179th St. @ I-5 NB on Ramp (2)	2.0	A	2.3	A
179th St. @ I-5 NB off Ramp (2)	22.7	C	24.8	C

-----  
 Note: All signal cycles are assumed to be 120 seconds in length.

- (1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.
- (2) Ultimate improvements assumed to be in place at this intersection. These include provision of additional travel lanes under I-5 on N.E. 179th Street, signalization at the northbound on-ramp and a northbound right turn only lane at the northbound I-5 off ramp.

Appendix K

Mitigation of Traffic Impacts  
with Access Via Both Salmon  
Creek and N.E. 29th Avenue

Table K-1

Summary of 1998 Levels of Service with Mitigation  
For Construction of WSU Campus  
Access Via Both N.E. 29th Avenue  
and Salmon Creek Avenue

Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-205 NB off Ramp (1)	13.2	B	13.3	B

(1) Install traffic signal.

Table K-2

Summary of 2010 Levels of Service with Mitigation  
For Construction of WSU Campus  
Access Via Both N.E. 29th Avenue  
and Salmon Creek Avenue

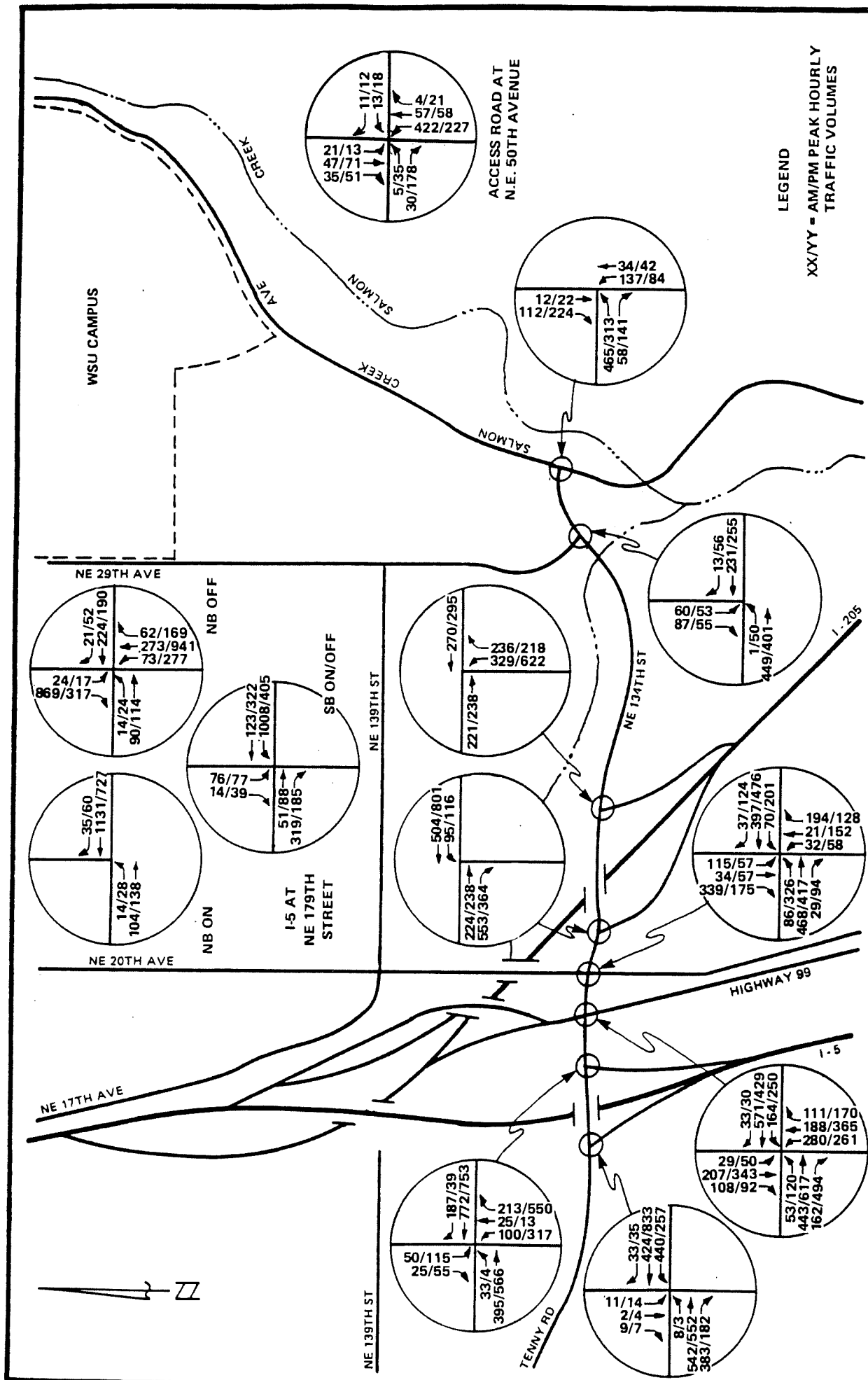
## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 NB off Ramp (1)	21.1	C	28.6	D
134th St. @ Hwy. 99 (2)	29.6	D	37.2	D
134th St. @ I-205 NB off Ramp (3)	13.8	B	14.2	B
139th St. @ 20th Avenue (4)	14.5	B	13.1	B

- (1) Includes addition of second northbound right turn lane (improvement to be made to accommodate 2010 background traffic volumes without WSU).
- (2) Add second southbound through lane and eliminate free east-bound right.
- (3) Install traffic signal and second northbound left turn lane. (Traffic signal to be added in 1998. Turn lane to be added to accommodate 2010 background traffic volumes without WSU).
- (4) Install traffic signal and north- and southbound left turn lanes.

Appendix L

1998 and 2010 Traffic Volumes  
and Levels of Service with  
N.E. 50th Avenue Access  
Alternative



1998 PEAK HOUR TRAFFIC VOLUMES  
WITH WSU - N.E. 50TH AVENUE ACCESS ALTE

**Kimley-Horn**

## FIGURE L-1



Table L-1

Summary of 1998 Levels of Service  
With Construction of WSU Campus  
N.E. 50th Avenue Access Alternative

## Stop Controlled Intersections

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Reserve Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	852	A	816	A
134th St. @ I-205 NB off Ramp	NBL	134	D	-217	F
	NBR	608	A	610	A
134th St. @ 29th Ave.	EBL	937	A	848	A
	SB(all)	396	B	377	B
134th St. @ Salmon Creek Ave.	NBL	849	A	844	A
	EB(all)	68	E	203	C
179th St. @ I-5 NB on Ramp	EBL	250	C	402	A
50th Ave. @ WSU Access	NBL	536	A	750	A
	SBL	977	A	986	A
	EBL	253	C	395	B
	EBR/T	967	A	802	A
	WB(all)	349	B	370	B

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Average Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	17.6	C	8.9	B
134th St. @ I-5 NB off Ramp (1)	16.8	C	23.2	C
134th St. @ Hwy. 99 (1)	27.7	D	29.5	D
134th St. @ 20th Ave. (1)	26.1	D	28.1	D
179th St. @ I-5 SB Ramps (2)	17.9	C	17.9	C
179th St. @ I-5 NB off Ramp (2)	26.0	D	18.3	C

Note: All signal cycles are assumed to be 120 seconds in length.  
 (1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.  
 (2) At N.E. 179th Street at I-5, proposed interim improvements are assumed to be in place.

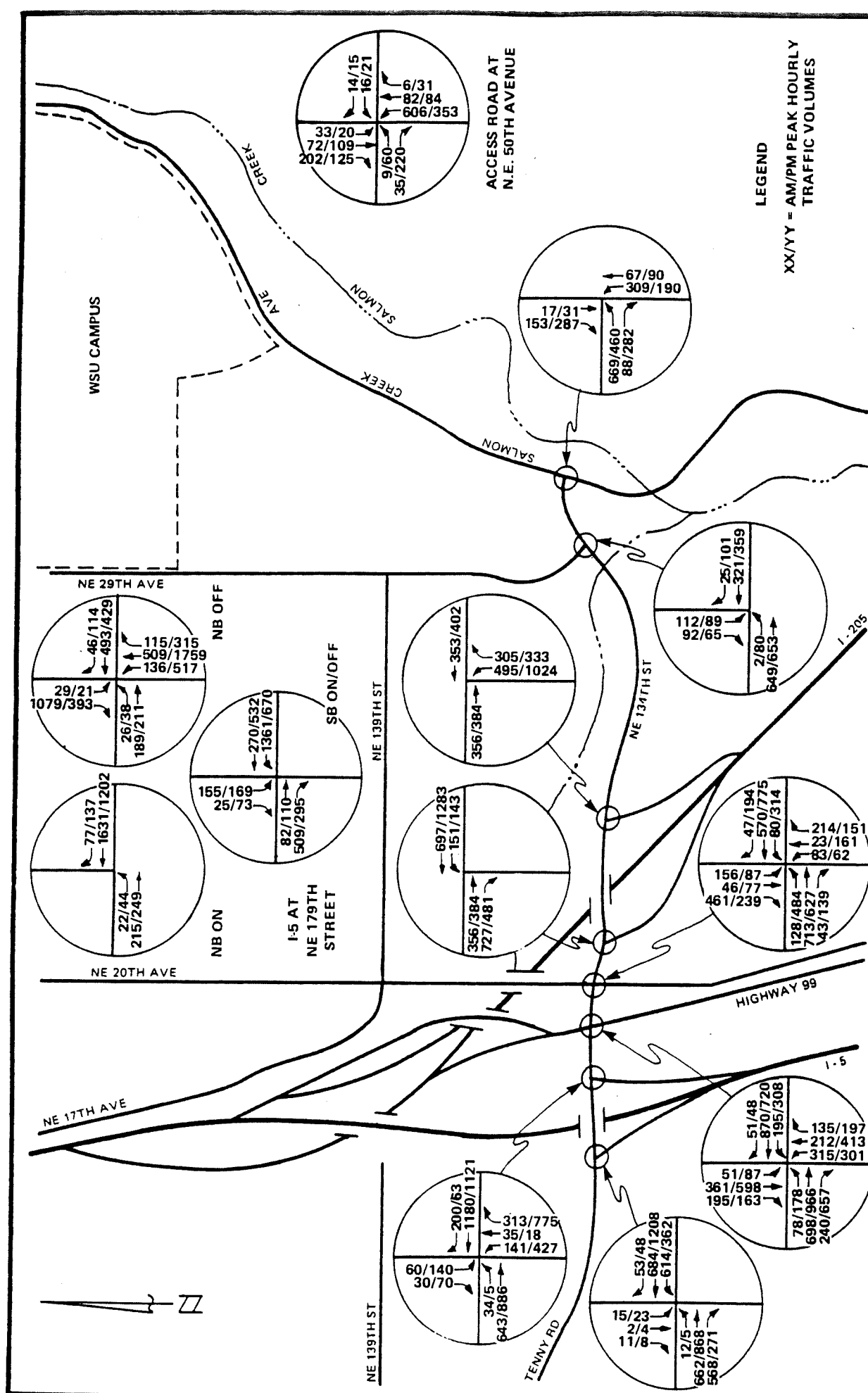


Table L-2

Summary of 2010 Levels of Service  
With Construction of WSU Campus  
N.E. 50th Avenue Access Alternative

## Stop Controlled Intersections

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	778	A	759	A
134th St. @ I-205 NB off Ramp	NBL	-135	F	-758	F
	NBR	501	A	449	A
134th St. @ 29th Ave.	EBL	952	A	758	A
	SB(all)	179	D	134	D
134th St. @ Salmon Creek Ave.	NBL	660	A	773	A
	EB(all)	-335	F	-203	F
50th Ave. @ WSU Access	NBL	612	A	333	B
	SBL	978	A	964	A
	EBL	221	C	113	D
	EBR/T	758	A	961	A
	WB(all)	220	C	141	D

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	28.2	D	12.0	B
134th St. @ I-5 NB off Ramp (1)	22.9	C	56.9	E
134th St. @ Hwy. 99 (1)	33.7	D	73.4	F
134th St. @ 20th Ave. (1)	31.9	D	38.1	D
179th St. @ I-5 SB Ramps (2)	31.2	D	25.9	D
179th St. @ I-5 NB on Ramp (2)	2.7	A	2.5	A
179th St. @ I-5 NB off Ramp (2)	22.7	C	24.8	C

Table L-2 Continued

- 
- Note: All signal cycles are assumed to be 120 seconds in length.
- (1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.
  - (2) Ultimate improvements assumed to be in place at this intersection. These include provision of additional travel lanes under I-5 on N.E. 179th Street, signalization at the northbound on-ramp and a northbound right turn only lane at the northbound I-5 off ramp.

Appendix M

Mitigation of Traffic Impacts  
with N.E. 50th Avenue Access  
Alternative

Table M-1

Summary of 1998 Levels of Service with Mitigation  
For Construction of WSU Campus  
N.E. 50th Avenue Access Alternative

**3-Way Stop Controlled Intersections**

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Capacity</u>	<u>LOS</u>
134th St. @ Salmon Creek Avenue (1)		NA	>C	NA	>C

**Signalized Intersections**

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-205 NB off Ramp (2)	14.2	B	16.1	C

- (1) Install 3-way stop signs.  
(2) Install traffic signal.

Table M-2

Summary of 2010 Levels of Service with Mitigation  
For Construction of WSU Campus  
N.E. 50th Avenue Access Alternative

**Stop Controlled Intersections**

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Capacity</u>	<u>LOS</u>
50th Ave. @ WSU Access (1)	NBL	612	A	333	B
	SBL	978	A	964	A
	EBL	249	C	131	D
	EBR/T	758	A	961	A
	WB(all)	220	C	141	D

**Signalized Intersections**

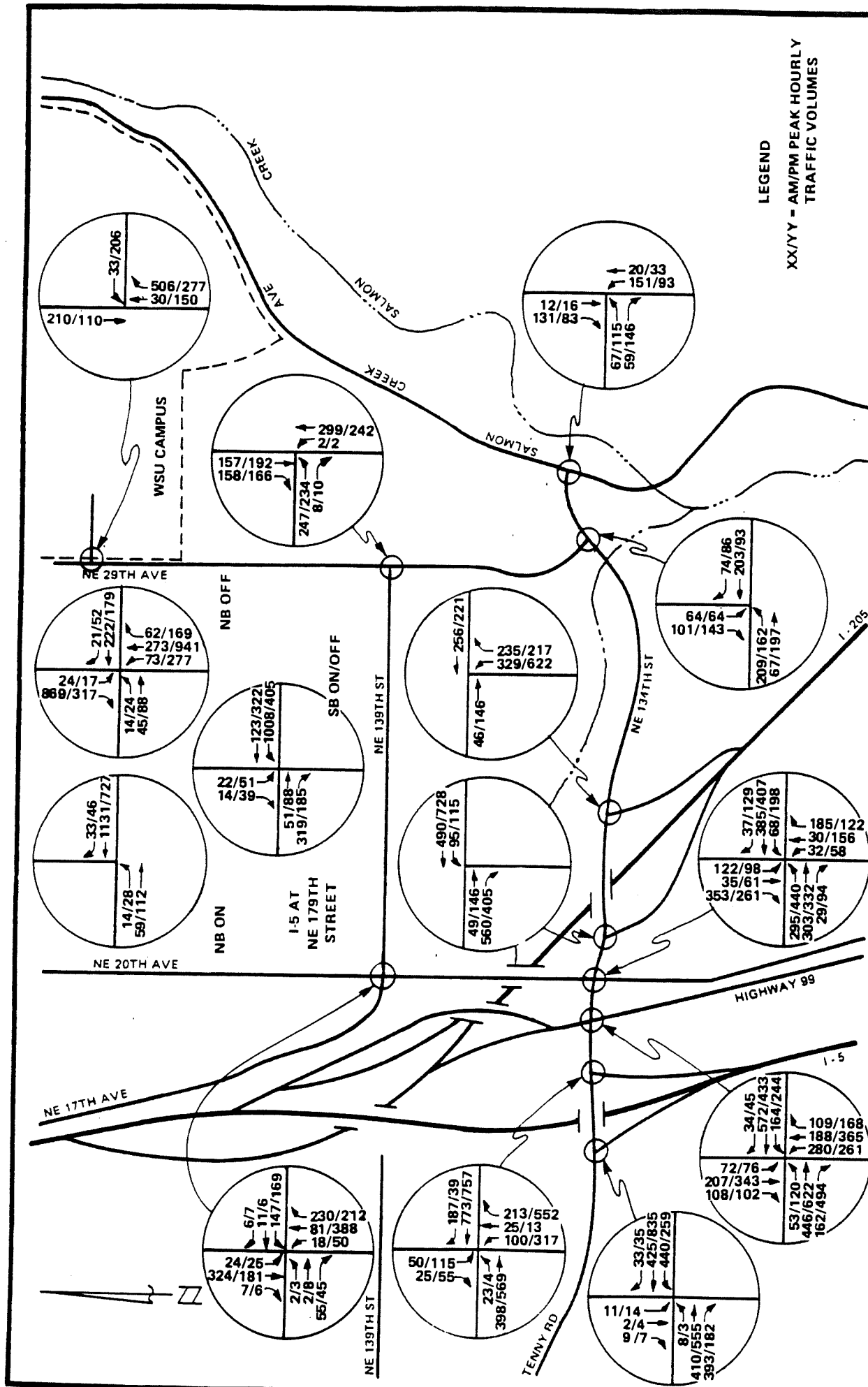
<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 NB off Ramp (2)	21.1	C	28.6	D
134th St. @ Hwy. 99 (3)	29.7	D	37.2	D
134th St. @ I-205 NB off Ramp (4)	15.1	C	17.6	C
134th St. @ 29th Ave. (5)	10.4	B	8.2	B
134th St. @ Salmon Creek Avenue (6)	25.7	D	19.5	C

- (1) Add southbound right turn lane.  
 (2) Includes addition of second northbound right turn lane (improvement to be made to accommodate 2010 background traffic volumes without WSU).  
 (3) Add second southbound through lane and eliminate free eastbound right.  
 (4) Install traffic signal and second northbound left turn lane. (Traffic signal to be added in 1998. Turn lane to be added to accommodate 2010 background traffic volumes without WSU).  
 (5) Install traffic signal.  
 (6) Install traffic signal and widen eastbound approach to provide separate left and right turn lanes.

Appendix N

1998 and 2010 Traffic Volumes  
and Levels of Service with  
N.E. 29th Avenue Access  
to/from South Only





**1998 PEAK HOUR TRAFFIC VOLUMES WITH WSU**  
**N.E. 29TH AVENUE ACCESS TO/FROM SOUTH ONLY**

**Kimley-Horn**

Table N-1

Summary of 1998 Levels of Service  
With Construction of WSU Campus  
N.E. 29th Avenue Access to/from South Only

**Stop Controlled Intersections**

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Reserve Capacity</u>	<u>LOS</u>
134th St @ I-205 SB on Ramp	WBL	895	A	873	A
134th St. @ I-205 NB off Ramp	NBL	267	C	-101	F
	NBR	741	A	708	A
134th St. @ 29th Ave.	EBL	677	A	822	A
	SB(all)	400	A	472	A
134th St. @ Salmon Creek Ave.	NBL	834	A	898	A
	EB(all)	601	B	548	A
139th St. @ 20th Ave.	NBL	839	A	939	A
	SBL	850	A	602	A
	EB(all)	652	A	587	A
	WB(all)	208	C	82	E
139th St. @ 29th Ave.	NBL	870	A	834	A
	EB(all)	190	D	217	C
179th St. @ I-5 NB on Ramp	EBL	251	C	410	A
29th Ave. @ WSU Access	WBL	744	A	439	A

**Signalized Intersections**

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Average Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	15.7	C	8.9	B
134th St. @ I-5 NB off Ramp (1)	16.1	C	23.0	C
134th St. @ Hwy. 99 (1)	27.8	D	30.8	D
134th St. @ 20th Ave. (1)	27.7	D	29.5	D

Table N-1 Continued

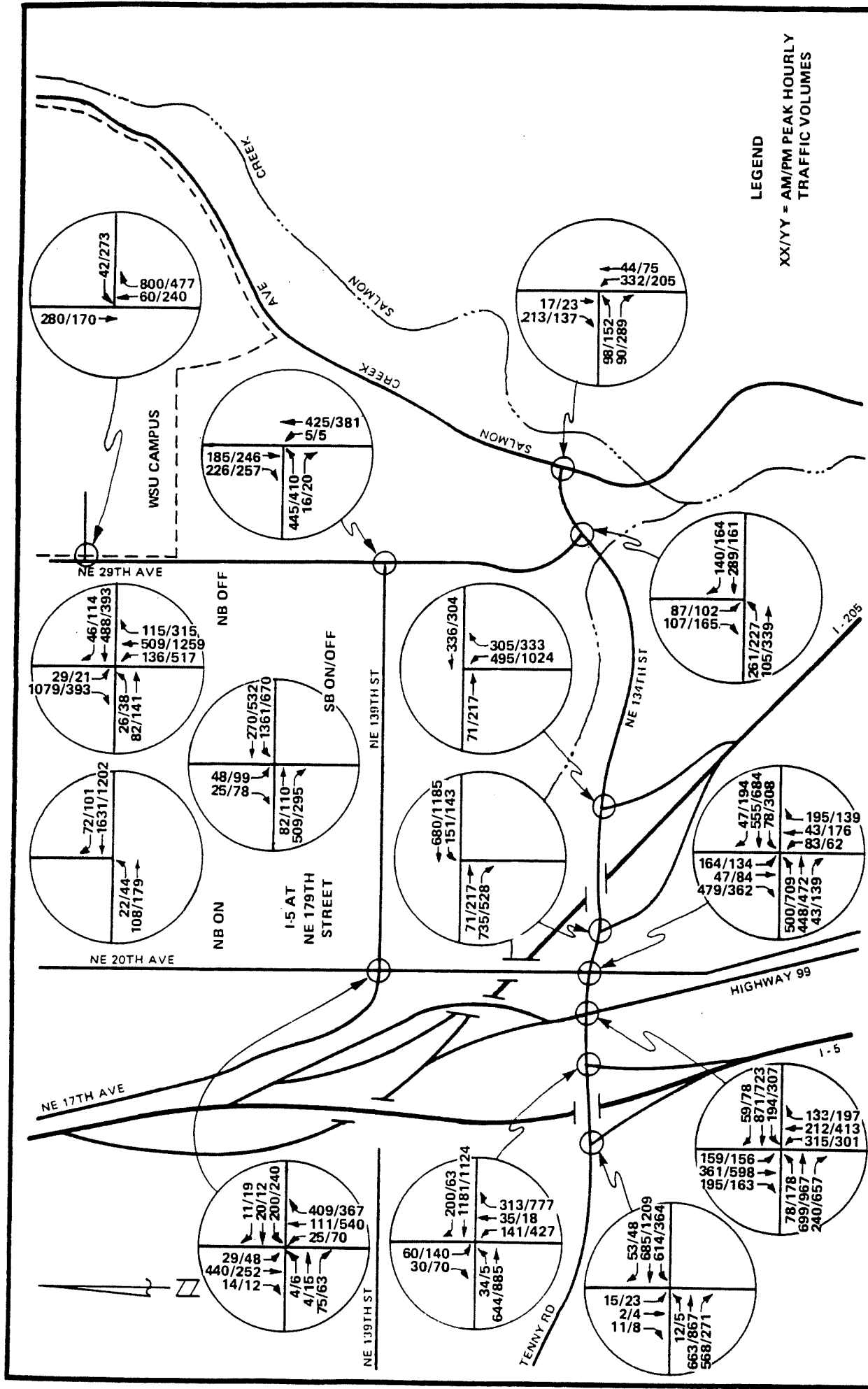
**Signalized Intersections**

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Average Delay</u>	<u>LOS</u>
179th St. @ I-5 SB Ramps (2)	15.3	C	16.9	C
179th St. @ I-5 NB off Ramp (2)	25.8	D	18.1	C

Note: All signal cycles are assumed to be 120 seconds in length.

(1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.

(2) At N.E. 179th Street at I-5, proposed interim improvements are assumed to be in place.



**2010 PEAK HOUR TRAFFIC VOLUMES WITH WSU  
N.E. 29TH AVENUE ACCESS TO/FROM SOUTH ONLY**

**FIGURE N-2**

**Klmley-Horn**

Table N-2

Summary of 2010 Levels of Service  
With Construction of WSU Campus  
N.E. 29th Avenue Access to/from South Only

## Stop Controlled Intersections

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	834	A	843	A
134th St. @ I-205 NB off Ramp	NBL	75	E	-591	F
	NBR	664	A	598	A
134th St. @ 29th Ave.	EBL	587	A	725	A
	SB(all)	247	C	211	C
134th St. @ Salmon Creek Ave.	NBL	635	A	774	A
	EB(all)	345	B	290	C
139th St. @ 20th Ave.	NBL	823	A	923	A
	SBL	761	A	469	A
	EB(all)	561	A	357	B
	WB(all)	41	E	-114	F
139th St. @ 29th Ave.	NBL	884	A	801	A
	EB(all)	-100	F	-82	F
29th Ave. @ WSU Access	WBL	347	B	148	D

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	28.3	D	12.1	B
134th St. @ I-5 NB off Ramp (1)	22.8	D	54.9	E
134th St. @ Hwy. 99 (1)	34.7	D	80.5	F
134th St. @ 20th Ave. (1)	36.0	D	39.8	D
179th St. @ I-5 SB Ramps (2)	22.2	C	22.0	C
179th St. @ I-5 NB on Ramp (2)	2.8	A	2.6	A

Table N-2 Continued

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average</u> <u>Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
179th St. @ I-5 NB off Ramp (2)	21.9	C	23.3	C

-----  
 Note: All signal cycles are assumed to be 120 seconds in length.

- (1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.
- (2) Ultimate improvements assumed to be in place at this intersection. These include provision of additional travel lanes under I-5 on N E. 179th Street, signalization at the northbound on-ramp and a northbound right turn only lane at the northbound I-5 off ramp

Appendix O

Mitigation of Traffic Impacts  
with N.E. 29th Avenue Access  
to/from South Only

Table O-1

Summary of 1998 Levels of Service with Mitigation  
For Construction of WSU Campus  
N.E. 29th Avenue Access to/from South Only

**4-Way Stop Controlled Intersections**

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Capacity</u>	<u>LOS</u>
139th St. @ 20th Ave. (1)		NA	>C	NA	>C

**Signalized Intersections**

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-205 NB off Ramp (2)	13.1	B	13.4	B

- (1) Install 4-way stop sign and stripe N.E. 20th Avenue for north and southbound left turn lanes.  
(2) Install traffic signal.



Table O-2

Summary of 2010 Levels of Service with Mitigation  
For Construction of WSU Campus  
N.E. 29th Avenue Access to/from South Only

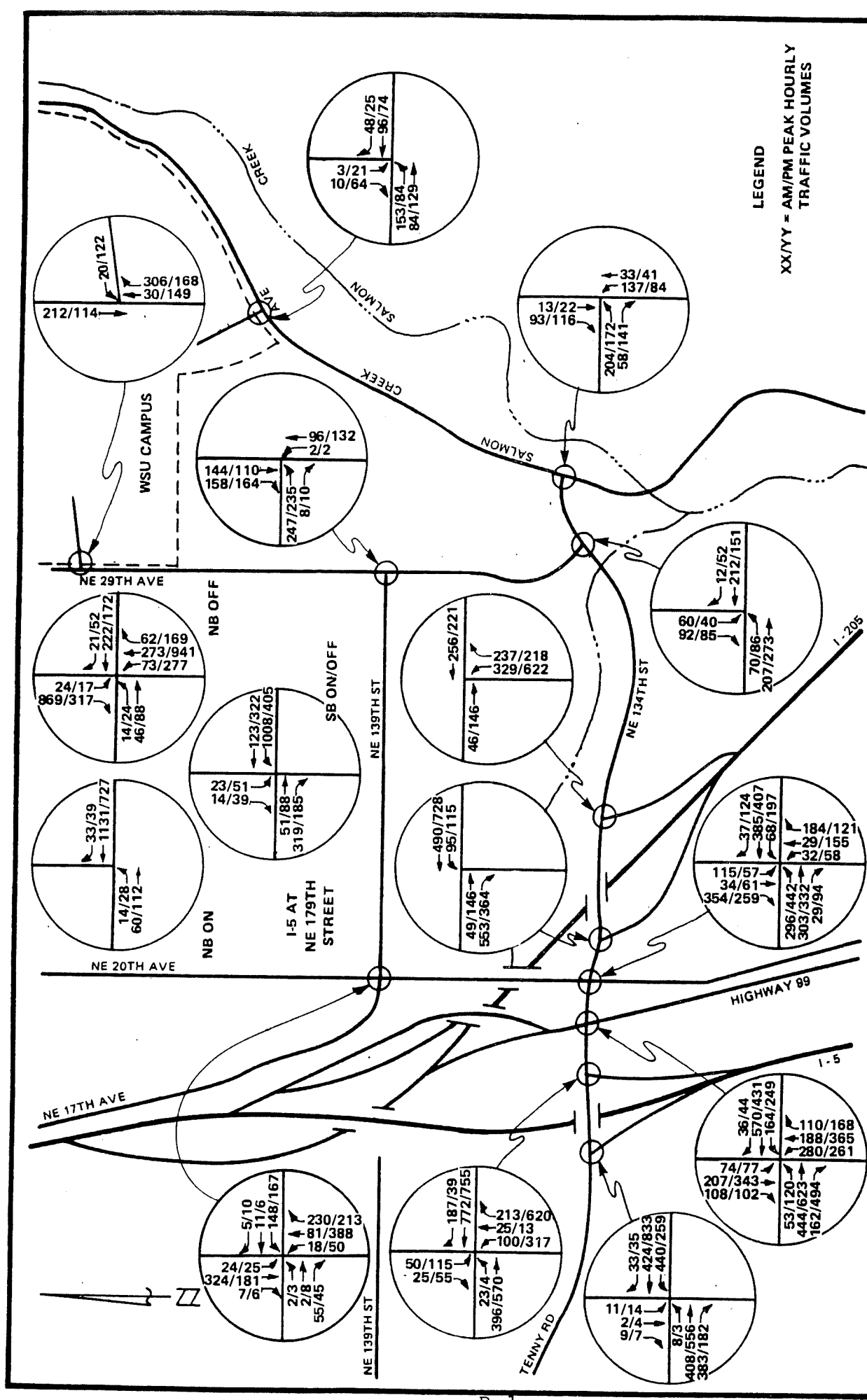
## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 NB off Ramp (1)	21.1	C	38.2	D
134th St. @ Hwy. 99 (2)	27.1	D	33.6	D
134th St. @ I-205 NB off Ramp (3)	14.7	B	13.9	B
139th St. @ 20th Ave. (4)	13.5	B	14.3	B
139th St. @ 29th Ave. (5)	16.3	C	15.0	B/C

- (1) Includes addition of second northbound right turn lane (improvement to be made to accommodate 2010 background traffic volumes without WSU).
- (2) Add second southbound through lane and eliminate free eastbound right.
- (3) Install traffic signal and second northbound left turn lane. (Traffic signal to be added in 1998. Turn lane to be added to accommodate 2010 background traffic volumes without WSU).
- (4) Install traffic signal.
- (5) Install traffic signal with northbound left and southbound right turn lanes.

Appendix P

1998 and 2010 Traffic Volumes  
and Levels of Service with  
Access at Salmon Creek Avenue  
and N.E. 29th Avenue to/from  
South Only



**1998 PEAK HOUR TRAFFIC VOLUMES WITH WSU ACCESS  
AT SALMON CREEK AVENUE AND N.E. 29TH AVENUE  
TO/FROM SOUTH ONLY**

**Kimley-Horn**

**FIGURE P-1**

Table P-1

Summary of 1998 Levels of Service  
With Construction of WSU Campus  
Access Via Both Salmon Creek Avenue and  
N.E. 29th Avenue Access to/from South Only

## Stop Controlled Intersections

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Reserve Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	895	A	873	A
134th St. @ I-205 NB off Ramp	NBL	267	C	-101	F
	NBR	739	A	707	A
134th St. @ 29th Ave.	EBL	880	A	882	A
	SB(all)	484	A	540	A
134th St. @ Salmon Creek Ave.	NBL	849	A	908	A
	EB(all)	393	B	445	A
139th St. @ 20th Ave.	NBL	839	A	939	A
	SBL	850	A	601	A
	EB(all)	652	A	587	A
	WB(all)	206	C	83	E
139th St. @ 29th Ave.	NBL	881	A	908	A
	EB(all)	340	B	350	B
179th St. @ I-5 NB on Ramp	EBL	251	C	414	A
Salmon Creek @ WSU Access	NBL	832	A	908	A
	EBL	522	A	569	A
	EBR	963	A	930	A
29th Ave. @ WSU Access	WBL	660	A	529	A

## Signalized Intersections

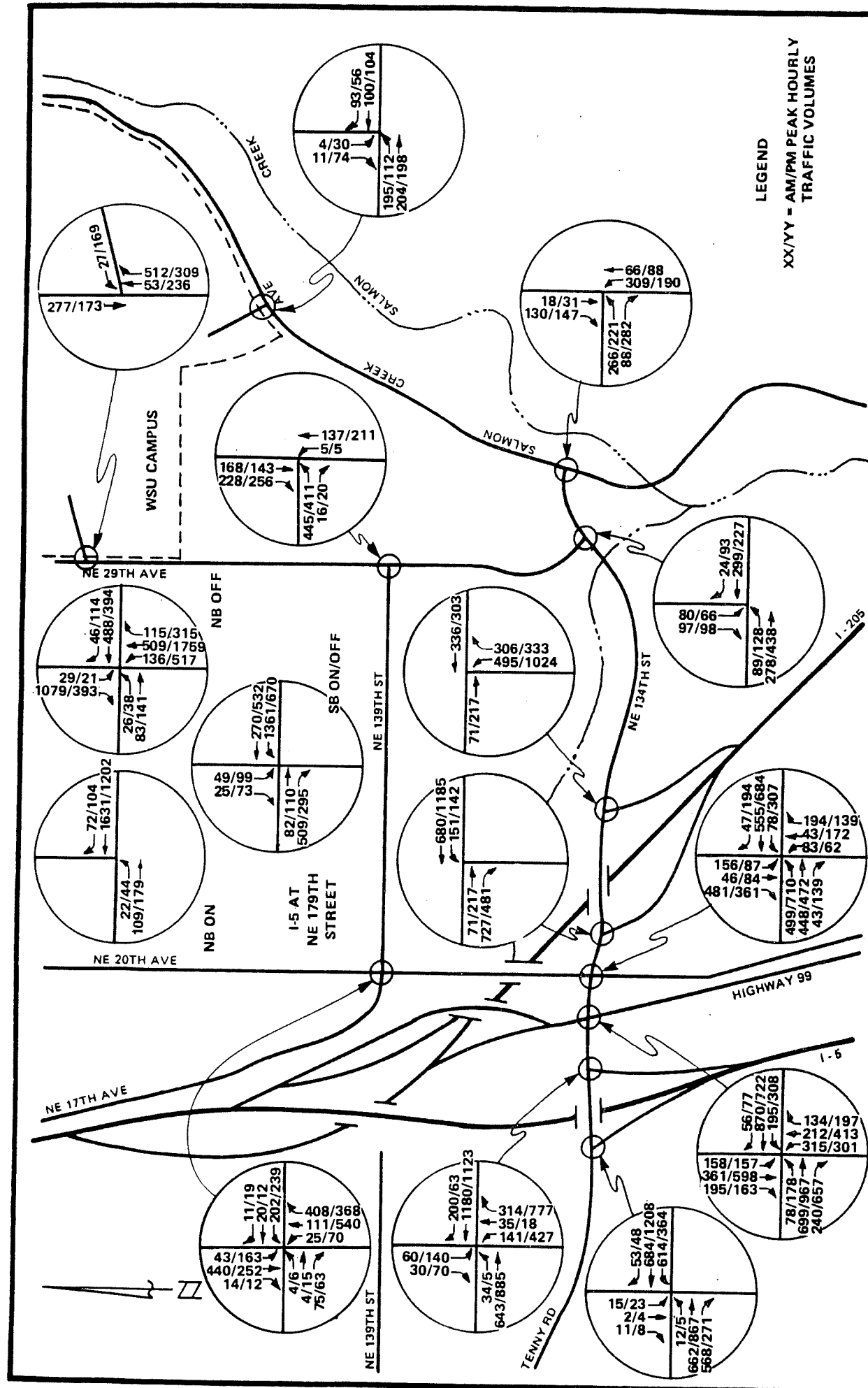
<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Average Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	15.7	C	8.9	B
134th St. @ I-5 NB off Ramp (1)	16.8	C	24.0	C
134th St. @ Hwy. 99 (1)	27.8	D	29.8	D

Table P-1 Continued

Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Average Delay</u>	<u>LOS</u>
134th St. @ 20th Ave. (1)	27.8	D	29.1	D
179th St. @ I-5 SB Ramps (2)	15.4	C	16.9	C
179th St. @ I-5 NB off Ramp (2)	25.8	D	18.1	C

Note: All signal cycles are assumed to be 120 seconds in length.  
 (1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.  
 (2) At N.E. 179th Street at I-5, proposed interim improvements are assumed to be in place.



**2010 PEAK HOUR TRAFFIC VOLUMES WITH WSU ACCESS  
AT SALMON CREEK AVENUE AND N.E. 29TH AVENUE  
TO/FROM SOUTH ONLY**



**FIGURE P-2**

Table P-2

Summary of 2010 Levels of Service  
With Construction of WSU Campus  
Access Via Both Salmon Creek Avenue and  
N.E. 29th Avenue Access to/from South Only

## Stop Controlled Intersections

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Capacity</u>	<u>LOS</u>
134th St. @ I-205 SB on Ramp	WBL	834	A	844	A
134th St. @ I-205 NB off Ramp	NBL	75	E	-590	F
	NBR	663	A	598	A
134th St. @ 29th Ave.	EBL	879	A	839	A
	SB(all)	378	B	328	B
134th St. @ Salmon Creek Ave.	NBL	660	A	791	A
	EB(all)	106	D	177	D
139th St. @ 20th Ave.	NBL	823	A	923	A
	SBL	747	A	342	B
	EB(all)	555	A	245	C
	WB(all)	29	E	-177	F
139th St. @ 29th Ave.	NBL	898	A	895	A
	EB(all)	106	D	96	E
Salmon Creek @ WSU Access	NBL	785	A	877	A
	EBL	436	A	513	A
	EBR	988	A	919	A
29th Ave. @ WSU Access	WBL	460	A	319	B

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 SB on Ramp (1)	28.3	D	12.1	B
134th St. @ I-5 NB off Ramp (1)	22.9	D	56.9	E
134th St. @ Hwy. 99 (1)	34.7	D	80.6	F
134th St. @ 20th Ave. (1)	34.8	D	38.5	D
179th St. @ I-5 SB Ramps (2)	22.2	C	22.0	C

Table P-2 Continued

Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average</u> <u>Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
179th St. @ I-5 NB on Ramp (2)	2.1	A	2.4	A
179th St. @ I-5 NB off Ramp (2)	21.9	C	23.4	C

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 Note: All signal cycles are assumed to be 120 seconds in length.  
 (1) At N.E. 134th Street in the vicinity of I-5, pending improvements are assumed to be in place.  
 (2) Ultimate improvements assumed to be in place at this intersection. These include provision of additional travel lanes under I-5 on N.E. 179th Street, signalization at the northbound on-ramp and a northbound right turn only lane at the northbound I-5 off ramp.



Appendix Q

Mitigation of Traffic Impacts  
with Access at Salmon Creek  
Avenue and N.E. 29th Avenue  
to/from South Only

Table Q-1

Summary of 1998 Levels of Service with Mitigation  
For Construction of WSU Campus  
Access Via Both Salmon Creek Avenue and  
N.E. 29th Avenue Access to/from South Only

4-Way Stop Controlled Intersections

<u>Intersection</u>	<u>Movement</u>	<u>AM Peak</u>		<u>PM Peak</u>	
		<u>Reserve Capacity</u>	<u>LOS</u>	<u>Capacity</u>	<u>LOS</u>
139th St. @ 20th Ave. (1)		NA	>C	NA	>C

Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-205 NB off Ramp (2)	13.2	B	13.4	B

- (1) Install 4-way stop sign and stripe N.E. 20th Avenue for north and southbound left turn lanes.  
(2) Install traffic signal.

Table Q-2

Summary of 2010 Levels of Service with Mitigation  
For Construction of WSU Campus  
Access Via Both Salmon Creek Avenue and  
N.E. 29th Avenue Access to/from South Only

## Signalized Intersections

<u>Intersection</u>	<u>AM Peak</u>		<u>PM Peak</u>	
	<u>Average Delay</u>	<u>LOS</u>	<u>Delay</u>	<u>LOS</u>
134th St. @ I-5 NB off Ramp (1)	21.1	C	38.1	D
134th St. @ Hwy. 99 (2)	27.0	D	33.8	D
134th St. @ I-205 NB off Ramp (3)	14.2	B	13.5	B
139th St. @ 20th Ave. (4)	13.6	B	15.9	C
139th St. @ 29th Ave. (5)	17.2	C	16.6	C

- (1) Includes addition of second northbound right turn lane (improvement to be made to accommodate 2010 background traffic volumes without WSU).
- (2) Add second southbound through lane and eliminate free east-bound right.
- (3) Install traffic signal and second northbound left turn lane. (Traffic signal to be added in 1998. Turn lane to be added to accommodate 2010 background traffic volumes without WSU).
- (4) Install traffic signal.
- (5) Install traffic signal.