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DEPARTMENT OF WATER AND WASTE MANAGEMENT

Richard D. Blinn, P.E.
Director

NOTICE OF ADOPTION

Revised Interim Stormwater Design Standards for New Development in Salmon Creek Basin

FROM: Richard Blinn, P.E.
Thurston County Drainage Manual Administrator

DATE: October 30, 2000

Section 1. SUMMARY

Effective immediately, **revised** interim stormwater standards for new development are imposed for the Salmon Creek Basin (the Basin). These standards replace interim standards imposed on the Basin pursuant to the Administrator's action dated February 9, 2000. These interim standards will remain in effect until further notice pending conclusion of the County's consultant work evaluating the extent and possible mitigations to groundwater flooding throughout the Basin. The completion date for this work is expected sometime during the fall of 2002. Basin boundary maps maintained by the Thurston County Storm and Surface Water Utility describe the boundaries for the Basin. Interim stormwater design minimum standards for new development in the Basin is presented below under Section 3.

Section 2. BACKGROUND

In response to recurrent groundwater flooding within the Basin, the Thurston County Board of County Commissioners (BoCC) expanded the existing Storm and Surface Water Utility Rate Boundary in August 1999. During late summer 1999, the BoCC imposed a moratorium on new development in groundwater flooding areas. During early fall 1999, staff prepared a work plan and solicited for consultant support. During October 1999, a contract was signed with URS Greiner Woodward Clyde to produce a calibrated ground and surface water model for the Basin. Following the successful delivery of these models, specific alternatives will be evaluated to determine long-term flood alleviation strategies for the Basin.

Responding to concerns from county residents, the BoCC voted to approve Critical Area Ordinance amendments addressing groundwater-flooding areas on February 7, 2000 (Ordinance #12155). These amendments provide additional requirements for new development in areas identified on the "Resource Map" for groundwater flooding as maintained by Thurston County Development Services Department. On February 7, 2000, the BoCC took action extending the building moratorium for four months for the Basin (Ordinance #12156); this moratorium has since been lifted.

Solid Waste Management, Storm & Surface Water Management, Water & Sewer Utilities Operations, Utility Development & Special Services
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Section 3. INTERIM DEVELOPMENT STANDARDS

A. **Purpose**: The County seeks to limit the adverse potential impact from new development within the Basin. To this end, the County is providing interim stormwater design standards for new development within the Basin. These standards will remain in place until such time that the County's consultant completes the modeling and alternative evaluation for flood alleviation strategies for the Basin. Upon review of the consultant's final basin report and recommendations, the interim standards will be reconsidered for ensuring consistency with the basin report.

B. **Interim Standards**: These interim standards are contained within "Interim Site Development Standards for New Development in Salmon Creek Basin", URS Greiner Woodward Clyde, October 6, 2000. These standards establish screening criteria for impact, new groundwater monitoring requirements, alter the manner in which new developments are modeled (hydrologic) and require groundwater-mounding analysis where appropriate. This additional guidance does not guarantee that new development can successfully complete the review process prior to the County completing the consultant modeling work. These interim standards are available upon request. Interested parties should contact Mark R. Cook, Storm and Surface Water Program Manager, at 360-754-4681 or visit 921 Lakeridge Drive SW, Building 4, Room 100, Olympia, WA 98502.

C. **Authority**: In taking this action, the Thurston County Drainage Manual Administrator is exercising the Administrative Authority of Section 1.2 of the <u>Drainage Design and Erosion Control Manual for Thurston County Washington</u>, 1994 (the Manual). Development proponents are encouraged to review "Interim Site Development Guidelines for New Development in Salmon Creek Basin" prior to submitting any drainage plan for review. The following list is not intended to be all-inclusive but does provide some direction on key chapters and sections of the Manual affected by the interim guidelines:

D. **Relationship to Manual Standards:**

- New screening criteria are established to determine preliminary impact thresholds for new development. The County has created a "Depth to Water" (DTW) map for use within the Basin. This map provides gross guidance on the probable water table elevation for Basin properties during extreme recharge events. Providing a minimum vertical separation of six feet from the bottom of proposed drainage facilities is maintained, design methods as detailed in the 1994 edition of the Manual may be used for new development.
- Providing that the screening criteria suggest that less than six feet of vertical separation exists, new monitoring requirements apply. Monitoring shall be for a period of one year. Proponents may elect to minimally monitor for a period of four months, two of which must be from the period described by December to March. Providing that this reduced monitoring period is elected by the proponent, the

monitoring shall continue until final stormwater plan preparation. Prior to final stormwater plan preparation, the proponent will provide all monitoring data with a statistical correlation to County reference wells. If this final analysis alters previous determinations regarding the preliminary stormwater plan, then additional mitigation of the stormwater plan shall be required.

- Section 3.1.1, Section 3, is amended to include the additional bore analysis requirement
- Section 3.1.1, Section 9, is amended to include input and output files from continuous simulation modeling and water balance analysis
- Section 4.1.1 is amended to reflect the requirement that any increase in off-site groundwater flooding or septic system failures due to recharge be prevented. Maximum release rates are amended to reflect the predeveloped runoff hydrograph as described by the continuous simulation model.
- Sections 4.1.2 is amended such that sizing is based on the results of the amended modeling requirements.
- Section 4.2 is amended to reflect the sizing as defined by the amended modeling requirements.
- Section 4.2.2 is amended to reflect the sizing as defined by the amended modeling requirements.
- Section 4.3 is amended to refer to Chapter 8, Section 8.5.3.
- Chapter 5 is replaced by the continuous simulation-modeling requirement. Existing condition is as described by aerial photography as captured by the County's 1996 flight.
- Section 8.5.3 is amended to require six feet of vertical separation.

Unless otherwise amended by "Interim Site Development Guidelines for New Development in Salmon Creek Basin", URS Greiner Woodward Clyde, October 6, 2000, all other Manual provisions apply.

Any questions regarding this administrative action, please contact Mark R. Cook, Storm and Surface Water Program Manager, at 360-754-4681.

cc: Board of County Commissioners
Linda Hoffman
URS Greiner Woodward Clyde
DPA Jeff Fancher
Fred Knotsman
Don Krupp
Mark R. Cook

MC:rp\interimmem_1000.doc

FINAL

INTERIM SITE DEVELOPMENT STANDARDS FOR NEW DEVELOPMENT IN SALMON CREEK BASIN

Prepared for
Thurston County
Department of Water and Waste Management
Storm and Surface Water Program

October 6, 2000

URS

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1.1 BACKGROUND

The Salmon Creek basin has experienced significant flooding problems during the past several years. High groundwater conditions appear to be the primary cause of the recent flooding. In August 1999, Thurston County imposed a six-month moratorium on new development in the basin to avoid increasing the flooding problems.

Thurston County is now conducting a study of groundwater and surface water conditions in the basin to (1) evaluate the causes and estimated recurrence frequency of the recent flooding; (2) estimate (using groundwater analysis) the approximate extent of high groundwater conditions outside the flooded areas that could flood basements or impair septic system drainfields; and (3) identify and assess alternative measures to mitigate the existing problem areas and avoid future problems.

In June 1998, Thurston County began installing a network of monitoring wells and stream gages to collect the data needed to develop groundwater and surface water models of the basin. Calibrated models should be available in June of 2001.

As an interim measure to ensure that new development within the basin does not exacerbate the extent of existing flooding, the County is requiring that new development meet additional drainage review criteria, under the authority of Section 1.2 of the Drainage Design and Erosion Control Manual for Thurston County, 1994. The interim standards for new development in the basin are described below. The interim standards define the procedure that project proponents must follow to obtain approval for new development in the Salmon Creek basin.

The interim standards outlined below are intended to guide new development in the Salmon Creek basin until the basin plan has been completed. The interim standards have two basic components:

- **Screening Evaluation.** Because of the past history of groundwater flooding in the Salmon Creek basin, Thurston County has established a basin-specific screening criterion regarding the vertical separation between the bottom of an infiltration facility and the high (winter 1999) groundwater elevation at the site. Statistical analyses indicate that the 1999 groundwater elevations are likely the highest that have occurred during the last 50 years. According to the basin-specific screening criterion, the maximum groundwater elevation must be at least 6 feet below the bottom of any infiltration facility at the site. Each project proponent must conduct a site-specific evaluation to determine whether their proposed development would meet this basin-specific screening criterion.
- **Performance Standards.** If the site-specific evaluation shows that the proposed project is unlikely to flood or exacerbate existing groundwater flooding problems, the project proponent may proceed with design. However, the design must meet basin-specific performance standards intended to minimize potential impacts on basin hydrology. In addition, continuous simulation modeling will be required to design stormwater facilities for some projects.

The screening evaluation and basin-specific performance standards are described below.

2.1 SCREENING EVALUATION

The screening evaluation involves the steps outlined below. Figure 1a provides an overview of the screening process.

Step 1 - Estimate depth to water under winter 1999 conditions. The project proponent must estimate the depth to water at their site under winter 1999 conditions, using the Depth-to-Water map recently prepared by Thurston County.

- If the Depth-to-Water map indicates more than 6 feet of separation between the 1999 groundwater elevation and the bottom of any infiltration facility at the site, the project proponent may proceed with design and permitting. The project must be designed to comply with the most current version of the County's Drainage Design and Erosion Control Manual.
- If the Depth-to-Water map indicates less than 6 feet of separation at the project site, the project proponent can either defer the project until the Salmon Creek Basin engineering analysis and plan have been completed, or perform site-specific groundwater measurements as described in Step 2.

Step 2- Measure groundwater elevations and estimate the winter 1999 groundwater elevations at the project site. The project proponent must install and monitor piezometers to obtain on-site groundwater elevations at the project site. The project proponent must also obtain groundwater elevation data for several "reference wells" that are monitored by the County. The project proponent must then perform a regression analysis to correlate the on-site water level data to the reference well data, and use the resulting regression equation to estimate the winter 1999 water levels at the project site. The required procedures for piezometer installation, water level measurement, reference well data acquisition, regression analysis, and estimation of on-site water levels are specified in *Use of On-site Wells and Reference Wells to Estimate Winter 1999 Groundwater Levels in the Salmon Creek Basin* (Appendix A). The key requirements are outlined below.

- **Piezometer Installation & Surveying.** For sites less than 5 acres, three piezometers will be required, unless the County Drainage Manual Administrator determines that fewer piezometers will be acceptable. For sites greater than 5 acres, the County Drainage Manual Administrator will specify the number of piezometers required. Piezometers must be installed at or near the topographic low point of the site and at planned locations of stormwater infiltration facilities. Piezometer locations should also allow for broad coverage of site conditions, including triangulation for groundwater flow direction determinations.

  The borings must be advanced to contact the uppermost lower-permeability unit (e.g., till). If no low-permeability unit is encountered within 50 feet of ground surface, the drilling can be terminated and a piezometer installed. Piezometer screen lengths shall be 20 feet and screens shall extend downward from the highest anticipated water table depth unless geologic field conditions indicate a shorter screen. Piezometers should screen only those geologic materials generally considered to be the Vashon recessional deposits (Qvr) and should not span substantial low permeability layers. Piezometer diameter shall be at least 1 inch. The elevation of the top of the piezometer (measuring point) must be surveyed to within 0.01 foot, based on the NGVD 29 vertical datum. The height of the measuring point above the mean natural ground level within a radius of 5 feet of the piezometer must be reported to 0.1-feet precision.

- **Piezometer Monitoring.** The County recommends monthly groundwater level monitoring for one year. However, for the purposes of this initial screening, a project proponent may elect to monitor weekly for as little as four months, provided the monitoring period includes at least two months within the December to March timeframe. The on-site groundwater elevations must be measured to within 0.01 foot using methods standard for the industry.

- **Reference Well Data Acquisition.** Thurston County has installed automated groundwater elevation measuring devices in several reference wells in the Salmon Creek basin. These reference wells have groundwater records extending back to at least the fall of 1998. Therefore, these wells provide a record of water level changes during the worst of the groundwater flooding in the winter of 1999. Current daily groundwater elevation data are also available for each reference well. The proponent must contact the County and acquire water level elevations from all reference wells for those dates with on-site water level measurements. If more than one measurement was collected for a particular well, the mean daily depth-to-water shall be calculated and used throughout. County data shall be used at 0.01-foot precision.

- **Estimation of Winter 1999 Groundwater Elevations at Project Site.** The project proponent must perform a regression analysis using the on-site water level data and the reference well water level data for the same dates. The proponent must then use the resulting regression equation to estimate the winter 1999 water levels at the project site.

  - If the reference well evaluation indicates that the site meets the screening criterion (i.e., at least 6 feet of separation between the winter 1999 groundwater elevation and the bottom of any infiltration facility at the site), the project proponent may proceed with design and preparation of the requisite permit applications. The project must be designed to comply with the most current version of the County's Drainage Design and Erosion Control Manual and the Performance Standards described below.

- If the reference well evaluation indicates that the site does not meet the screening criterion (i.e., less than 6 feet of separation between the winter 1999 groundwater elevation and the bottom of any infiltration facility at the site), the proponent can either defer the project until the Salmon Creek Basin engineering analysis and plan have been completed, or conduct a site specific groundwater mounding analysis as described in Step 3.

Step 3 - Conduct site-specific groundwater mounding analysis. The project proponent may perform a site-specific mounding analysis to assess the potential impacts of the proposed project on neighboring properties. An HSPF continuous simulation model must be prepared for the project site to estimate pre- and post-development recharge rates. The HSPF model must be prepared using the parameter values and precipitation data provided by the County. The proponent must estimate the maximum water level that would occur given the same precipitation conditions that led to the winter 1999 groundwater levels, and considering discharge of imported potable water to drainfields. The mounding analysis must be conducted in accordance with the "Groundwater Mounding Analysis Guidelines" (Appendix B). Appendix C provides guidelines for County review of mounting analyses.

- If the site-specific groundwater mounding analysis shows that the proposed project will not increase groundwater elevations at the project site property line, the project proponent may proceed with the design and preparation of requisite permit applications. Stormwater facilities must be sized using the HSPF model developed for the project site, and the design must comply with the Performance Standards described below.

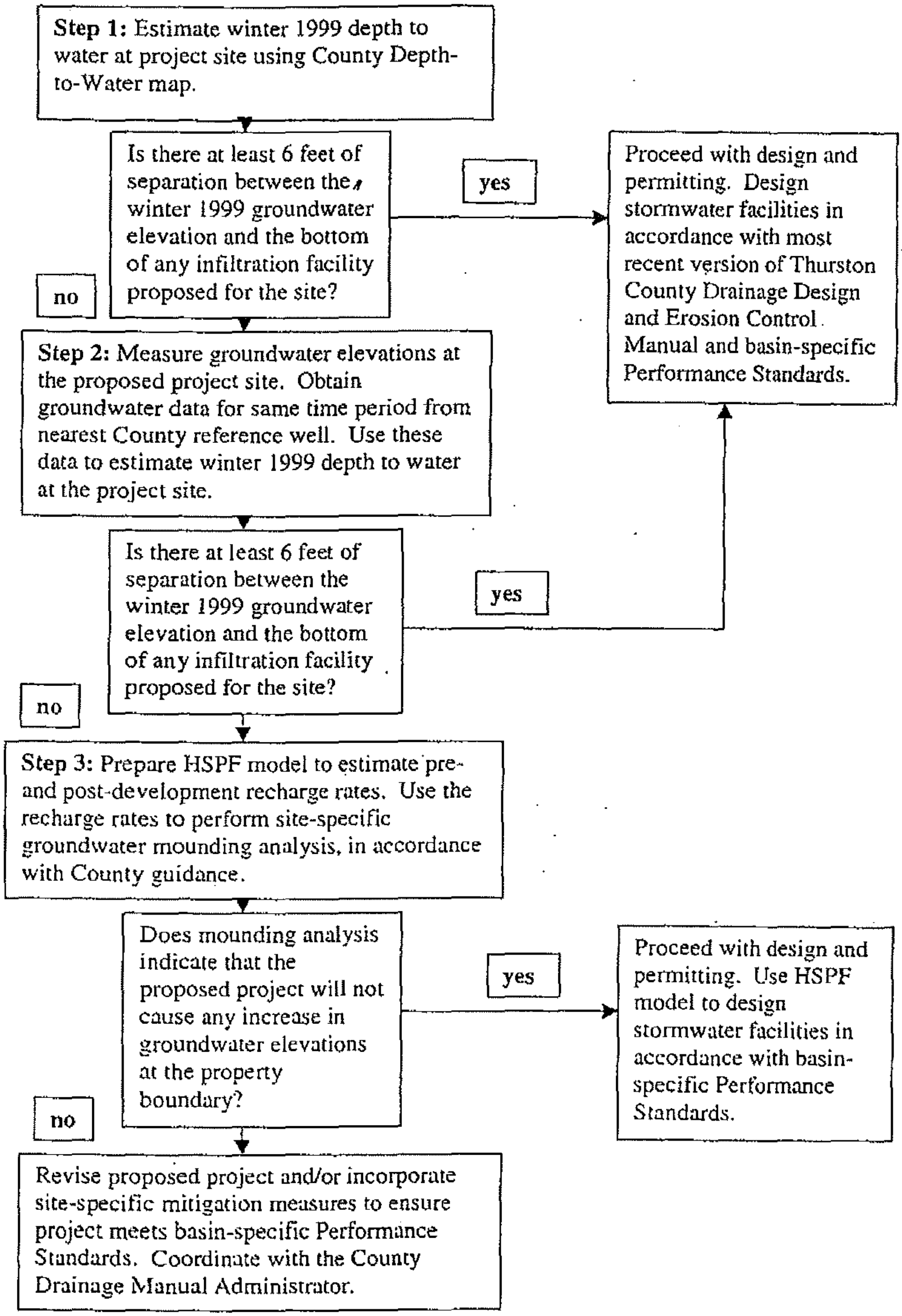
- If the groundwater mounding analysis indicates that the proposed project would cause an increase in groundwater levels at the property boundary, the project proponent must revise the proposed project and provide site-specific mitigation as needed to avoid such impacts.

2.2 PERFORMANCE STANDARDS

Proposed projects that pass the screening evaluation must be designed to meet all of the applicable requirements of the most recent version of the County's Drainage Design and Erosion Control Manual for control of surface water runoff. All new developments in the Salmon Creek basin must be designed to prevent on-site flooding for antecedent precipitation equivalent to that preceding the 1999 flooding, and prevent any increase in off-site groundwater flooding or septic system failures due to increased recharge (or runoff) from the site.

As noted above, the HSPF continuous simulation model must be used to design stormwater facilities for projects that require a groundwater mounding analysis (Step 3 above), and these projects must be designed so that they will not increase groundwater elevations at the property line.

Figure 1a. Interim Screening Evaluation Process for Salmon Creek Basin



Appendix A

Use Of On-Site Piezometers and Reference Wells for Estimation of Winter 1999 Groundwater Levels

Pacific Groundwater Group
2377 Eastlake Ave. E.
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206.329.0141 FAX 329 6968

MEMORANDUM

To: Mark Cook, Thurston County
From: Charles T. Ellingson, Pacific Groundwater Group

Re: **USE OF ON-SITE PIEZOMETERS AND REFERENCE WELLS FOR ESTIMATION OF WINTER 1999 GROUNDWATER LEVELS**

Date: October 6, 2000

Introduction

If predicted depth-to-groundwater below a proposed stormwater infiltration facility is less than 6 feet based on the County's depth-to-water map for winter 1999, the proponent may collect new on-site depth-to-water data, correlate the new on-site data to new data from a reference well, then use the correlation to estimate on-site depth-to-water in the winter of 1999. The purpose of this document is to specify the requirements for on-site data collection and correlation analysis. The general procedure is also discussed in the County's *Interim Site Development Standards for New Development in Salmon Creek Basin.*

Step 1 - Install On-Site Piezometers

a. The project proponent must install three or more piezometers on the project site. For sites less than 5 acres, three piezometers will be required, unless the County Drainage Manual Administrator determines that fewer piezometers will be acceptable. For sites greater than 5 acres, the County Drainage Manual Administrator will specify the number of piezometers required. Piezometers must be installed at or near the topographic low point of the site and at planned locations of stormwater infiltration facilities. Piezometer locations should also allow for broad coverage of site conditions, including triangulation for groundwater flow direction determinations. Proponents should discuss piezometer locations with the County prior to installation.

The borings must be advanced to contact the uppermost substantial lower-permeability unit (expected to be till over most of the basin) or to a depth of 50 feet, which ever is less. Piezometer screen lengths shall be 20 feet and screens shall extend downward from the highest anticipated water table depth unless geologic field conditions indicate a shorter screen. Piezometers should only screen only the Vashon recessional deposits (Qvr) and screens and sand packs should not span substantial low permeability layers. Piezometer diameter shall be at least 1 inch.

b. The elevation of the top of the piezometer (measuring point) must be surveyed to within 0.01 foot, based on the NGVD 29 vertical datum. The height of the measuring point above the mean natural ground level within a radius of 5 feet of the piezometer must be reported to 0.1-feet precision.

c. Detailed logs of piezometers shall be generated and include at least the following information:

- geologic log
- drilling method
- sampling methods and intervals
- construction log showing piezometer and annular-space materials and dimensions (referenced to ground surface).
- elevation of the measuring point (top of piezometer) to 0.01-foot precision and referenced to the NGVD29 vertical datum
- State-plane north and east coordinates
- height of the measuring point above the mean ground level within a radius of 5 feet around the well
- drilling company name
- date of completion

Step 2 - Monitor On-Site Water Levels

The project proponent must monitor groundwater elevations in their on-site piezometers. The County recommends monthly groundwater level monitoring for one year. However, for the purposes of this screening, a project proponent may elect to monitor weekly for as little as four months, provided the monitoring period includes at least two months within the December-to-March timeframe. Depth-to-water in the piezometers must be measured to within 0.01-foot precision using methods standard for the industry. Measurements must be referenced to the surveyed measuring point (top of piezometer) and corresponding water-table elevations must be calculated.

Step 3 - Identify Most Appropriate County Reference Well and Generate Linear Regression Relationships

Thurston County has installed automated groundwater elevation measuring devices in several reference wells in the Salmon Creek basin (**Figure 1**). These reference wells have groundwater records extending back to the fall of 1998 (**Figure 2**). Therefore these wells provide a record of water level changes during the groundwater flooding period in the winter of 1999. Current daily groundwater elevation data are also available for each reference well.

a. The proponent must contact the County and acquire water level elevations from all reference wells for those dates with on-site water level measurements. If more than one measurement was collected for the reference well on the required day, the mean daily depth-to-water shall be calculated and used throughout. County data shall be used at 0.01-foot precision.

b. The proponent shall identify the reference well that will provide the best approximation of data from each on-site piezometer by calculating linear correlation parameters for each on-site piezometer/reference-well pair. The reference well with the highest correlation coefficient shall be selected.[1] A table showing the relationship between data from a hypothetical on-site piezometer and reference wells is shown in **Figure 3**. The reference well with the highest correlation coefficient for each piezometer shall be identified and used for further evaluations, as shown in **Figure 3**. The proponent shall prepare a table and graph similar to those on **Figure 3** for each on-site piezometer. Each figure shall show the correlation coefficients for each piezometer/reference-well pair, the best-fit line for the selected piezometer/reference-well pair, and the equation for the line.

If the linear correlation is poor using all of the data pairs (maximum $r^2 < 0.7$), or if the best-fit line through all the data pairs deviates from the data trend more than 2 feet at the highest recorded water level, a modified approach should be attempted. The analysis is most critical at high elevation because the equation for the best-fit line will be used to predict groundwater elevations that are higher than any measured on site.

In the case of a poor match to high elevation data, the proponent should first review the scatter-grams for other reference wells. If the best-fit line for an alternative reference well matches high-elevation data pairs and the correlation coefficient is only marginally below that of the maximum, the alternative reference well should be selected.

If alternative reference wells do not improve the match to high elevation data pairs, the proponent should remove low-elevation data pairs from the correlation and generate a new best-fit line. Best-fit lines using all the data pairs and a truncated data set are shown on **Figure 3**. As indicated on **Figure 3**, removing 6 data pairs decreased r^2 but improved the match between the line and the highest-elevation data pair. Whether or not such a modification is likely to improve the predictive capability of the resulting best-fit line at high elevation will depend on the degree of confidence in the field data and the number of high-elevation data pairs upon which to judge the match. These are project-specific factors that will require consideration by the proponent and County. In the example of **Figure 3** only one high-elevation data pair exists and the modified approach is probably not justified.

[1] See standard statistical text books for definition of the correlation coefficient, r. A convenient method of calculating coefficients and plotting best-fit lines is to use a commercial software package such as Microsoft Excel.

Non-linear correlation approaches are discouraged because they can result in physically unrealistic relationships, particularly outside the field-data range. Nonetheless, the County will consider non-linear approaches that result in physically realistic predictions if the linear approaches described herein do not result in physically realistic predictions. The proponent must present and justify any non-linear approaches in a manner similar to that specified for the linear approaches herein.

Step 4 - Estimate Winter 1999 Depth to Water

The proponent must estimate a winter-1999 groundwater elevation in each on-site piezometer by using historical reference well data and the variables A and B from the best-fit line.

a. The proponent shall calculate the maximum average elevation of groundwater in the selected reference wells for any 10-day period between January 15, 1999 and May 15, 1999 – rounded to the nearest 0.1-foot. A 10-day running average of groundwater elevation between those dates is therefore required.

b. The proponent shall then estimate winter-1999 groundwater elevations in each on-site piezometer to 0.1-foot precision using the equations for the best-fit lines: The linear equations will have the form:

$$E_{on\text{-}site} = M * E_{reference} + B$$

where:

$E_{on\text{-}site}$ =	elevation of on-site groundwater
$E_{reference}$ =	maximum 10-day average groundwater elevation in reference well during the winter of 1999
M =	slope of best-fit line
B =	intercept of best-fit line

The variables M and B will be generated by the best-fit correlation between each piezometer and reference well as shown in **Figure 3**. Non-linear relationships would have different variables but the approach is the same.

c. Finally, depth-to-water shall be calculated to 0.1-foot precision by subtracting the maximum average winter-1999 elevation of groundwater in each piezometer from the local ground surface elevation from Step 1. In some cases the proponent may wish to create a depth-to-water map in addition to the piezometer-specific calculations. The map could be generated by contouring the groundwater data from on-site piezometers and subtracting the elevation contours from land surface elevation contours.

Step 5 - Calculate Groundwater Flow Direction

The groundwater elevation data for the maximum- and minimum elevation measurement rounds shall be contoured (separately). The contour maps shall indicate groundwater flow direction.

Step 6 - Report to County

An *On-Site Depth-to-Water Report* shall be submitted to the County and shall include at least the following:

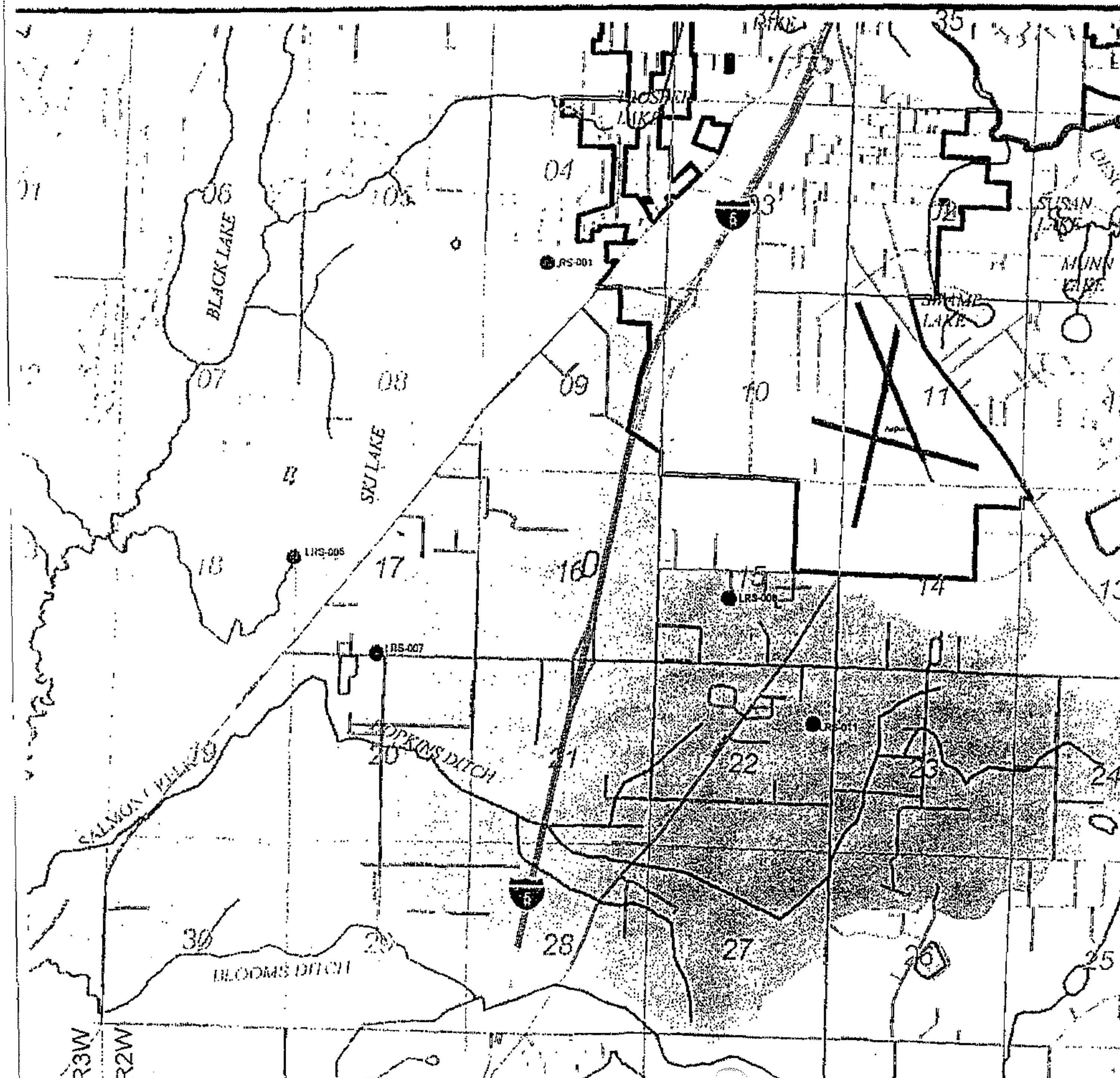
- vicinity map showing the site and surrounding properties, buildings, roads, parcels, and hydrography
- site map showing piezometer locations and land surface elevation contours (two-foot contours are available from the County for all of the Salmon Creek basin)
- brief interpretation of on-site shallow geology
- geology/piezometer logs
- table of piezometer survey data
- table of on-site water level measurements
- table of reference well water level measurements
- table of piezometer/reference well correlation parameters
- scattergram (graph) of piezometer/reference well data pairs, showing best-fit line(s) and equation(s)
- table showing on-site maximum 10-day groundwater elevations and minimum depths-to-water from winter 1999
- groundwater contour maps of maximum and minimum measured water level elevations

Step 7 - County Interpretation

The County will review the report for consistency with these requirements. If the work is found to have been performed in reasonable conformance with these requirements and in general conformance with accepted hydrogeologic practices, the County will evaluate the depth-to-water criteria.

If the estimated (winter 1999) depth-to-water below a proposed stormwater infiltration facility is greater than 6 feet, the County will inform the proponent that the site has passed the screening evaluation identified in the *Interim Site Development Standards for New Development in Salmon Creek Basin*. If the depth to water is 6 feet or less, the County will inform the proponent that they can either defer the project until the Salmon Creek Basin engineering analysis and plan have been completed, or perform a site specific groundwater mounding analysis as described in *Groundwater Mounding Analysis Guidelines*.

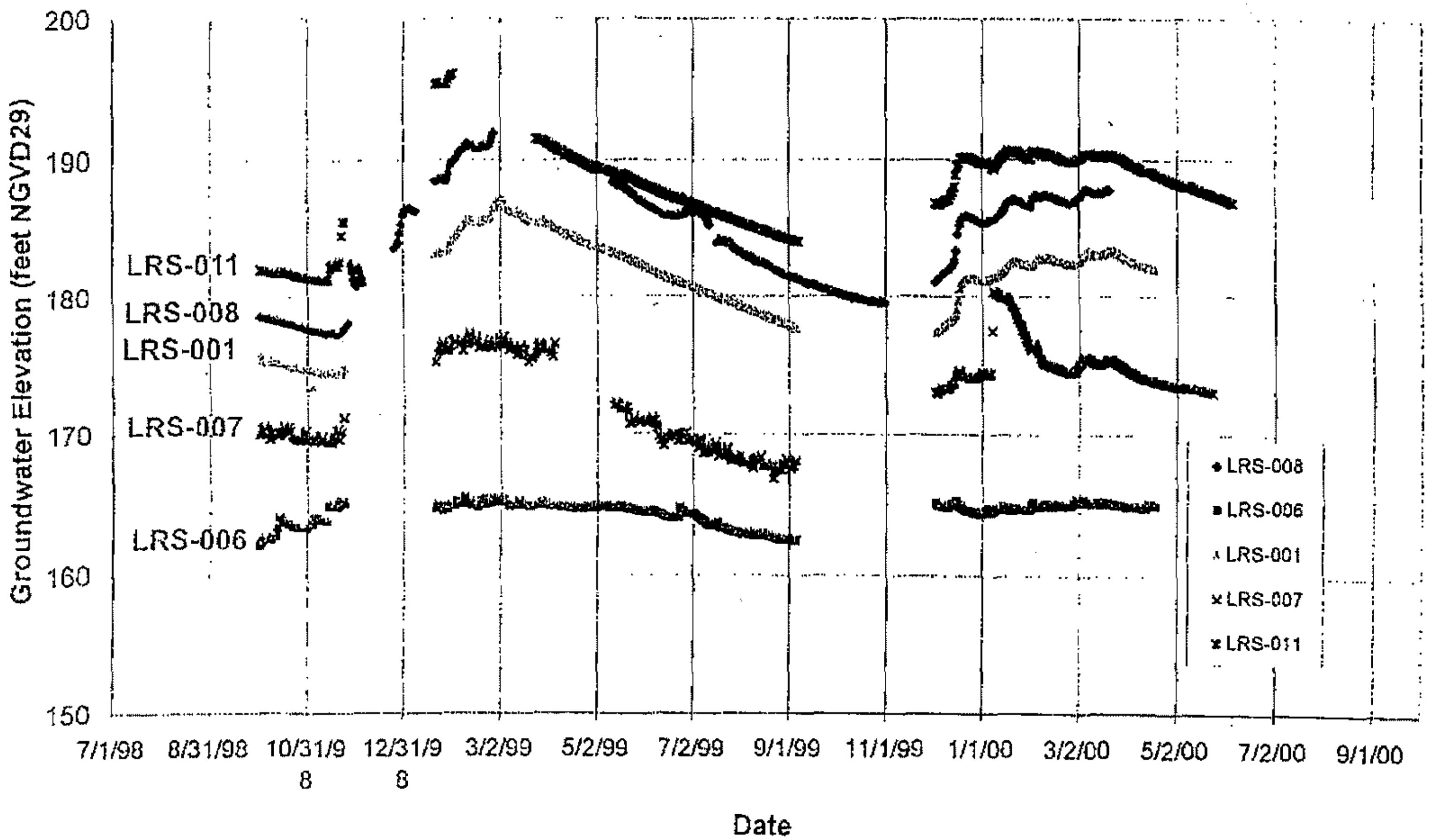
Figure 1
Reference Well Locations



Reference Wells
Tumwater City Limits
Salmon Creek Surface Water Basin (Thurston County)

Pacific Groundwater Group

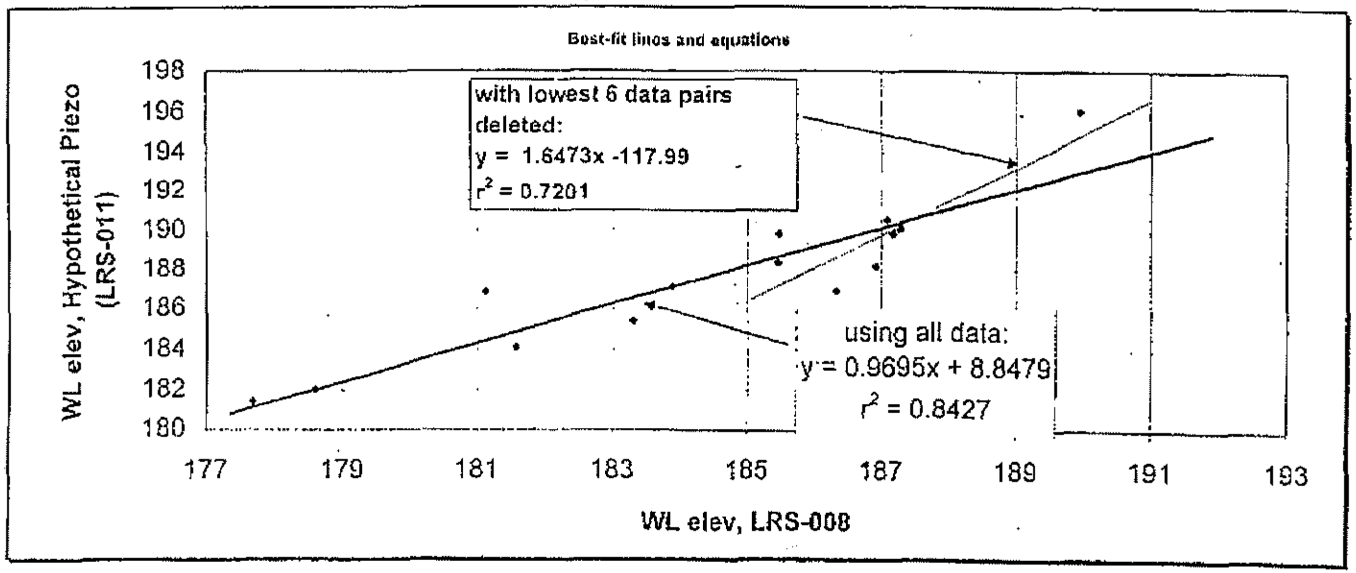
Figure 2 - Hydrographs for Reference Wells



Pacific Groundwater Group

Figure 3. Correlation of Hypothetical Piezometer and Reference-Well Data

Reference Well	using all data pairs r^2	Correlation coefficient, r	M (slope)	B (intercept)
LRS-001	0.811	0.901		
LRS-006	0.554	0.744		
LRS-007	0.696	0.834		
LRS-008	*0.843*	*0.918*	*0.9695*	*8.8479*



Pacific Groundwater Group

Appendix B

Groundwater Mounding Analysis Guidelines

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MEMORANDUM

To: Mark Cook, Thurston County
From: Charles T. Ellingson, Pacific Groundwater Group

Re: **GROUNDWATER MOUNDING ANALYSIS GUIDELINES**

Date: October 6, 2000

Introduction

If predicted depth to groundwater is less than 6 feet based on the County's *Interim Site Development Standards for New Development in Salmon Creek Basin*, the proponent may perform a groundwater mounding analysis to try to demonstrate conformance with basin-specific Performance Standards as defined in the *Interim Standards*. The purpose of this mounding analysis guide is to specify the software, input data, calibration requirements, and output format for the referenced groundwater analyses. In general, the guidelines result in an estimate of the effects of site development on groundwater levels in the unconfined aquifer (a. k. a., water table) during the winter and possible exacerbation of groundwater flooding.

Processes that must be considered are:

- changes to average recharge quantity over the site as a result of changes in evapotranspiration.
- distribution of recharge on site (pavement and stormwater infiltration plans), and
- quantity and distribution of imported water supplies that will be disposed to drainfields, leak from pipes, or infiltrate as a result of excess irrigation.

Summary of Standard Approach

The proponent must develop a simplified, 2-dimensional, transient, finite difference groundwater model to simulate groundwater mounding under the current and built conditions. The County anticipates mounding as a result of increased total recharge caused by reduced use of water by plants (land clearing) and discharge of imported potable water through septic drainfields. The current- and built-condition models shall be the same, except for recharge quantity and distribution. Heads (groundwater levels) under the current condition shall be subtracted, on a cell-by-cell basis, from heads under the built condition. The recharge conditions used to evaluate the change shall be average recharge for each month (12 values) of water years 1997, 1998, and 1999 (October 1, 1996 through September 30, 1999) as calculated by an HSPF model also generated by the proponent using standardized properties defined by the County. The County will not approve projects that are predicted by this analysis to cause increased winter or spring heads at the proponent's property boundary. The County will apply this criterion using a precision of whole feet – in other words, results shall be rounded to the nearest foot. Projects will not be approved unless the predicted change at the property boundary in winter and spring is 0 feet.

Sources of Hydrogeologic and Hydrologic Information for the Area

Several sources of background information about the hydrogeologic environment in and near the Salmon Creek drainage basin are readily available. The most up-to-date are the *Hydrology and Quality of Ground Water in Northern Thurston County, Washington* (Drost and others, 1998), the report on 3-dimensional groundwater modeling of Thurston County (Drost and others, 1999), and the *Salmon Creek Drainage Basin Conceptual Hydrologic Model and Data Collection Plan* (Pacific Groundwater Group, 2000). Detailed information on local conditions also may be found in well logs on file with Dept. of Ecology (Southwest Regional Office, Lacey, WA) and in hydrogeologic reports on drilling and testing of water-supply wells and monitoring wells in the area. Many of the latter are listed in the bibliography of the Pacific Groundwater Group (2000) report.

Software and Computer Requirements

The project proponent must use either the MODFLOW or PLASM finite-difference modeling code to estimate changes due to proposed development.

The simple conceptual model to be simulated shall be two-dimensional and consist of a single-layer, unconfined aquifer with an impermeable base. Cell sizes shall be commensurate with the project size and details of site layout. Because of the need to account for mounding near infiltration ponds, cell sizes at the ponds must be small, yet the model boundaries must be sufficiently distant to not unacceptably-influence model results. Therefore, although all models will be simple, most will have large numbers of cells and users are cautioned against using a slow computer, or one with insufficient memory. Also, model versions with advanced pre- and post-processors are highly recommended.

Flexibility

These guidelines are designed to reduce work required of a proponent by specifying a set of acceptable, yet simplified, requirements. A proponent may modify these guidelines if the modifications are approved by the County Drainage Manual Administrator and result in a more realistic model. Additional simplifying assumptions are unlikely to be approved.

Although conceptually reasonable, these model requirements have not been "tested" and therefore modifications may be necessary during modeling to achieve reasonable results. For instance, the current-condition model should not predict surface flooding, if such conditions were not observed or expected based on field conditions. Also, the gradient of the uniform flow field may need to be altered to approximate the average measured hydraulic gradient – given that areal recharge also will be applied to the model.

Model Plan

The proponent shall review these guidelines and site data and then prepare a brief plan for modeling the site. The plan should be submitted to the County Drainage Manual Administrator for comment. The memo should include any proposed deviations from the standard approach that are deemed necessary by the proponent at that early stage. The County will comment on the plan; however, given unknowns that may arise during modeling, the County cannot assure that the plan will result in an acceptable model nor overall approval of the project.

Standard Model Domain and Grid Design

The model domain shall extend to ten times the project-site dimensions in all directions from the project boundary (with allowance for square cells approximating an irregular property boundary), unless the proponent demonstrates that a model with a smaller domain is equally insensitive to boundary conditions.

Model cells shall be sufficiently small to simulate the influence of stormwater infiltration ponds; however, because the model is numerical, the maximum groundwater-mound height will not be calculated by the model, and the model should not be solely relied upon for design purposes. The pond design must also be based on the County Drainage Manual. Stormwater ponds shall be modeled using no fewer than 4 model cells unless the pond is smaller than 400 square feet, in which case a single model cell may be used.

The distribution of impervious surfaces does not have to be explicitly simulated by arranging the model cells. However, the modeler must attempt to replicate the distribution of recharge given normal grid-design constraints. Also, the site-wide water balance must be maintained by any averaging process used to define recharge in cells with mixed land-surface coverage.

Given the small model cells required for stormwater-pond simulation, the number of cells used to simulate the project site (parcels) will likely be high and dictated by the following standard limitation on cell-size rates-of-change: *the length of adjacent cells shall not differ by more than a factor of 1.5*. The project area should be closely approximated by cell boundaries.

Standard Boundary Conditions

The simplified model shall consist of a uniform gradient equal to the average gradient as indicated by mapping the synoptic water-level data collected by Thurston County on March 20, 2000 (Groundwater-Basin Boundary and Synoptic Water-Level Survey for Salmon Creek Area, Pacific Groundwater Group, 2000). Model boundaries shall consist of a constant-head boundary up-gradient, either a constant-head or general-head downgradient, and no-flow boundaries on the sides of the model to create the uniform flow field. The superposition of areal recharge on the uniform flow field will alter the uniform flow field, and the modeler may need to adjust the heads at constant head or general-head boundaries in order to maintain reasonable saturated thicknesses and gradients in the project vicinity.

Pre-Calibration Aquifer Properties

The single layer shall be modeled as an unconfined aquifer (transmissivity shall be sensitive to head). Recommended pre-calibration aquifer properties are: hydraulic conductivity of 150 ft/d, based on Drost and others (1999), and a specific yield (S_y) of 0.25, based on mean values for fine to medium sand (Johnson, 1967). The layer thickness shall be site-specific, if known; otherwise the values from Drost and others (1999) may be substituted. Drost and others indicate that upper aquifer (Qvr) thickness is between 25 and 50 feet over most of the basin.

Current-Condition and Built-Condition Models

Current and built-condition models shall differ only in recharge quantity and distribution. The differences in recharge quantity shall be calculated by HSPF modeling using standard parameter and precipitation data provided by the County plus calculated discharges from septic drainfields. Septic drainfield discharges shall be based on existing Thurston County guidelines. Differences in recharge distribution shall be dependent on the development proposal and must consider locations of stormwater infiltration and the area, and approximate distribution, of impervious surfaces.

Standard Time Descretization

Both the current-condition and built-condition models shall have stress periods of one month and time steps established using the default (Modflow or PLASM) method. Both the current-condition and built-condition models must simulate transient conditions in order to estimate average head for each month. However, because the modeling goal is to simulate long-term changes in head, a cyclic, quasi-steady-state condition shall be achieved by simulating twelve one-month stress periods in a repetitive fashion for as many years (cycles) as necessary to reach approximate steady-state. Cyclic steady-state conditions shall be assumed when the head in all cells change by less than 0.05-feet from one year to the next for each monthly simulation period.

Standard Monthly Recharge

Input to the current-condition groundwater model shall consist of the average recharge rate for each month (12 values) as calculated by a site-specific, current-condition HSPF continuous-simulation model considering water years 1997, 1998, and 1999. The HSPF model must be prepared using the parameter values and precipitation data provided by the County. Attachment A to this memorandum contains more detailed guidance on generating recharge from the HSPF model.

The built-condition model must be exactly the same as the current-condition model except that recharge quantity and distribution shall be based on site-development plans (including septic discharge) and the output from a site-specific, built-condition HSPF continuous-simulation model. Average recharge shall be calculated for each month (12 values) considering HSPF modeling results for water years 1997, 1998, and 1999. Assumed septic discharge quantity shall be based on existing Thurston County guidelines.

Standard Convergence Criterion

The volumetric water budget for both models must balance to less than 1% in order to demonstrate convergence of the mathematical processing.

Current-Condition Model Calibration

A truly calibrated model is not required or appropriate given the simplified approach. However, since seasonal water-level fluctuations are the focal point of the analysis, some calibration to seasonal water-level fluctuation is required. Typical inter-season head changes were 7 to 12 feet at three in-basin wells, as summarized in the *Salmon Creek Drainage Basin Preliminary Conceptual Hydrologic Model and Data Collection Plan* (Figures 10, 11, and 13; Pacific Groundwater Group, 2000).

The proponent shall use measurements from on-site piezometers or representative off-site data to calibrate the current-condition model to seasonal water-level fluctuation. If less than one-year of on-site data are available, the proponent shall predict seasonal water level fluctuations by correlating on-site data to County reference well data (see "*Use of On-Site wells and Reference Wells to Estimate Winter 1999 Groundwater Levels in the Salmon Creek Basin*", Pacific Groundwater Group, October 2000). The aquifer's hydraulic conductivity, thickness, and specific yield may be modified within generally accepted ranges for on-site material types to achieve calibration. Recharge shall not be altered. Exact replication of measured water levels from specific years should not be expected (and is not required) unless HSPF recharge data from those specific years is used in calibration (not the time-averaged HSPF data specified as the standard approach).

Standard Data Reduction and Presentation

Models shall be documented completely in a report to the County, using standard model-reporting practices. The documentation shall include maps and tables defining:

- grid design superimposed on site-development plans and regional features
- aquifer hydraulic properties
- boundary definitions

- recharge quantities
- head output
- other model features, if implemented
- documentation of cyclic steady-state, model convergence, and calibration

In addition, specific output shall be generated to allow efficient evaluation of the County criteria. This output shall consist of hydrographs (head versus time) of the cyclic steady-state heads generated by the current- and built-condition models (two lines on one graph). The heads shall be from the last time step of each stress period. A third plot of the difference between the current- and built-condition heads over time shall also be provided, along with tabular data for each plot shall. These hydrographs shall be provided for the following key model cells:

- the cell with the highest head below each stormwater infiltration pond
- the cell just outside the property boundary downgradient of each stormwater pond
- the cell just outside the property boundary closest to each stormwater pond
- one cell just outside the property boundary along each segment of the property boundary (in other words - cells to represent typical conditions along each segment of the property line)

References

Drost and others, 1998, *Hydrology and quality of groundwater in northern Thurston County, Washington.* U. S. Geological Survey, Water-Resources Investigation Report 92-4109 (revised), Tacoma, WA.

Drost and others, 1999, *Conceptual model and numerical simulation of the ground-water-flow system in the unconsolidated sediments of Thurston County, Washington.* U. S. Geological Survey, Water-Resources Investigation Report 99-4165, Tacoma, WA.

Johnson, A. I., 1967, *Specific yield – compilation of specific yields for various materials.* U. S. Geological Survey, Water-Supply Paper 1662-D, 74 p.

Pacific Groundwater Group, 2000, *Salmon Creek drainage basin, preliminary conceptual hydrologic model and data collection plan.* prepared for Thurston County Water and Waste Management.

Prickett, T. A. and Lonnquist, C. G., 1971. *Selected digital computer techniques for groundwater resource evaluation.* Illinois State Water Survey Bulletin No. 55, Champaign, IL, 62 p. (later nicknamed PLASM for Prickett-Lonnquist Aquifer Simulation Model).

ATTACHMENT A
TO
GROUNDWATER MOUNDING ANALYSIS GUIDELINES

Precipitation recharge shall be calculated for each groundwater model cell using HSPF. An additional component will be included to represent discharge of septic effluent. The following steps will be involved:

Outside the proposed developed boundary:

Since there are no changes proposed for this area, recharge will be the same between existing and built conditions.

1. Simulate historical precipitation records with long-term PET data between 1955/1/1 and 1999/12/30 for the combined total area outside the proposed developed boundary. Simulating storm events prior to water year 1997 is required to establish the correct initial soil condition prior to 1997.
2. Recharge shall be composed of three components in HSPF: Surface outflow (SURO), interflow outflow (IFWO) and groundwater outflow (AGWO). The monthly sum of these three components between October 1, 1996 and September 30, 1999 (water years 1997, 1998, and 1999) shall be output.
3. Calculate the recharge rate (length per time) for each off-site model cell using the HSPF recharge totals and HSPF areas.

Within the proposed developed parcels:

A detailed model is necessary to evaluate the impact to groundwater due to the development. For existing conditions, the procedure is same as the one described for the area outside the proposed developed boundary. The following steps summarize procedures for the built condition:

1. The surface outflow (SURO) from the proposed developed parcels will be assigned to recharge in the cells associated with the storm water infiltration facility, assuming all the storm water runoff will be carried to the facility by a conveyance system. If more than one infiltration facility is proposed, land area attributable to each facility should be delineated and separate calculations for each facility should be made.
2. In addition to the above, interflow (IFWO) and groundwater outflow (AGWO) should be calculated for the total developed site and be distributed as recharge throughout the groundwater model cells within the proposed developed parcels.
3. Recharge resulting from discharge of septic effluent shall also be distributed to groundwater model cells. A uniform distribution across the developed area is an acceptable approximation of actual septic discharge unless a community drainfield is proposed, in which case the actual location of the drainfield shall be simulated.

The table below summarizes the way the different recharge terms shall be distributed in the groundwater model:

	surface runoff	interflow	groundwater	septic
Existing Condition	distribute	distribute	distribute	NA
Built Condition	to stormwater pond	distribute	distribute	distribute unless a community drainfield is proposed