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Recd 6/25/01
AEK

Memorandum

To:	Keith Smith, Port of Seattle
From:	Charles Ellingson, Pacific Groundwater Group
Re:	Modeled Area and Hydrus Model Results Draft Interim Deliverables
Date:	June 25, 2001

This memo presents the following interim draft deliverables related to Hydrus/Slice modeling of third runway fill:

- Definition of the area to be modeled by Hydrus/Slice instead of HSPF
- Effective Recharge
- Selection of Cross Sections (locations for Slice models)
- Fill thickness
- Definition of soil as modeled in Hydrus
- Draft Interim Hydrus Modeling Results

Definition of the Area to be Modeled by Hydrus/Slice Instead of HSPF

PGG used existing GIS coverages of existing topography, "built" topography, and third runway pavement distribution to calculate areas for Hydrus/Slice modeling. The areas to be modeled by Hydrus and Slice (and therefore removed from HSPF) are shown on **Figure 1** and **Table 1**. The areas include proposed additional runway fill in the Miller and Walker Creek basins minus the steep slopes along the western edge of the constructed fill.

The north-south extent of the fill within the Miller Creek and Walker Creek basins will be used along with other data to integrate Slice model results along the respective basin lengths. A dashed line is drawn on **Figure 1** between the Miller and Walker Creek Basins. The location of the line is approximately the same as the co-incident surface water and groundwater basin boundaries used within the HSPF models (Parametrix SMP Figure B2-2). The areas indicated in **Table 1** below are consistent with the line drawn on **Figure 1**. The basin areas to be modeled by Hydrus/Slice are as follows:

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Table 1

Summary of Areas to be Modeled by Hydrus/Slice

	Miller Creek Basin	Walker Creek Basin
Pervious Fill Area	3,030,620 sq ft	450,630 sq ft
Runway and Taxiway Impervious Area	1,833,928 sq ft	260,743 sq ft
Total Area in Basin to be modeled by H-S	4,864,548 sq ft	711,373 sq ft

Runoff from impervious area (IA) is assumed to infiltrate in pervious areas (PA). Therefore the impervious and pervious areas in **Table 1** above are used to calculate effective recharge on pervious areas. IA in Walker creek consists of only the western half of the runway because runoff from the eastern half will not flow onto new third runway fill.

Effective Recharge

Effective recharge was calculated using the following algorithm which is called "recharge 1":

- *AquaTerra applied daily precipitation between 1984 and 1994 to grass on flat outwash in HSPF (regional parameters)*
- *the resulting daily recharge (R) was increased to account for secondary infiltration of runoff from impervious surfaces using the following formula for effective recharge (ER):*

$$ER=R+(R*(IA/PA))$$

While this method accounts for runoff from the impervious areas, we acknowledge that it employs a lower-end estimate of impervious runoff. Impervious runoff is underestimated because it is assumed equal to the recharge rate below grass on outwash soils. In actuality, the impervious areas will lose less water to evapotranspiration than grass would, and would therefore have more water available for runoff to the pervious area. The simplifying assumption that runoff rates equal calculated recharge rates was adopted to facilitate the timeline of the modeling exercise. However, we performed additional analysis on whether an upper-end estimation of runoff from impervious areas is not likely to cause significant overland flow in the pervious areas. Based on conversations with team members, the following algorithm (called "recharge 2") was used to assess the upper-end estimation of runoff:

- *AquaTerra increased precipitation (P) to account for runoff from impervious surfaces to pervious surfaces using the following formula for effective precipitation:*

$$EP=P+(P*IA/PA))$$

- *AquaTerra applied EP between water years 1984 to 1994 for grass on flat outwash in HSPF (regional parameters)*

The sum of daily "recharge 1" over the 11-year period was 18.7% less than the sum of daily "recharge 2" over the same period. This result suggests that the difference in runoff from the two methods is relatively small, and that recharge 1 may underestimate actual recharge. **Figure 2** is a plot of Miller Creek ER as calculated by "recharge 1" and "recharge 2". Walker Creek has a very similar IA/PA ratio and therefore similar ER.

Selection of Cross Sections (Locations for Slice Models)

PGG reviewed hydrogeologic conditions and embankment geometries along the extent of the embankment fill. Three representative hydrogeologic cross sections were selected using available subsurface data and interpretations. Cross sections 1 and 2 are representative of conditions within the thicker Miller Creek basin fill while cross section 3 is representative of conditions in the Walker Creek basin fill and the southern, thinner portion of the Miller Creek fill. Hydrogeologic cross sections will be used to create Slice models.

Cross sections are based on subsurface data described in available geotechnical and hydrogeologic reports and from the existing and proposed topography of the third runway area. PGG compiled and reviewed consulting reports completed since the Ecology Study in order to select cross section alignments. The following is a brief summary of each cross section. **Figure 1** shows the approximate locations of cross sections.

Cross Section 1 (Slice 1): This cross section is located through the thickest portion of the fill embankment with a fill thickness of up to 160 feet. Cross section 1 is located at the same location as the original slice model used by PGG in the Ecology study. **Figure 3** presents the schematic cross section upon which the Slice 1 model will be based.

Cross Section 2 (Slice 2): This cross section is located through the northern portion of the fill embankment near the northern end of the proposed third runway. Cross section 2 was developed from a generalized hydrogeologic cross section originally created by Hart Crowser through the northern toe of the fill embankment (Hart Crowser, 1999) and from supplemental test pit data in this area. **Figure 4** presents the schematic cross section which will be used as the basis for the Slice 2 model. The third runway fill in Cross Section 2 is thinner than Cross Section 1. Soil unit designations to be used in the slice model are also shown.

Cross Section 3 (Slice 3): This cross section is located immediately north of the South MSE wall. A fill thickness of up to 23 feet occurs in this slice. Cross section 3 was based on a generalized hydrogeologic cross section originally created by Hart Crowser through the northern end of the MSE wall study area (Hart Crowser, 2000b). It was updated based on supplemental geotechnical data (Hart Crowser, 2000c), existing and proposed topography, and available till mapping data. **Figure 5** presents the schematic cross section which will be used as the basis for the Slice 3 model. Soil-unit designations to be used in the slice model are also shown.

Only Cross Section 3 will be used to represent subsurface conditions within the Walker Creek basin fill. The section was chosen through fill of intermediate thickness. Although this single section will not accurately represent the variety of fill thicknesses in Walker Creek basin fill, the thick portion of the fill is of small areal extent.

Fill Thickness

The thickness of fill is mapped on **Figure 1** based on pre- and post- construction topography as provided in existing GIS coverages. A series of Hydrus models was used to represent discrete values of fill thickness over the observed range.

Definition of Soil as Modeled in Hydrus

Soils are defined in Hydrus using variables that relate hydraulic conductivity to moisture content and soil tension. For this modeling exercise, soils were defined the same way as they were for the modeling work done for the Ecology project (Sea-Tac Runway Fill Hydrologic Studies Report, PGG, 2000). Appendix C of PGG (2000) provides a detailed description of the fill soils and modeled soil parameters.

Draft Interim Hydrus Modeling Results

Separate one-dimensional Hydrus models were run for fill thicknesses of 10, 30, 50, 70, 90, 110, 130, and 150 feet in both the Miller and Walker Creek basins (as dictated by the thicknesses observed on the cross sections). In addition, a 20-foot model was developed for Walker Creek only. **Figure 6** shows daily effective recharge (input to the top boundary of all Hydrus models) and eight daily outflow graphs (flow out of the bottom boundary of the Hydrus model) for the Miller Creek basin over the "test period" of October 1, 1990 through September 30, 1994. Conservation of mass was confirmed for each model by comparing the total effective recharge and total outflow. Time series outflow from Hydrus runs of varying thicknesses will be used as input to the three Slice models.

Figure 6 shows that the seasonal recharge pulse introduced at the land surface (ER) is predicted to be lagged and dampened as a function of the thickness of the fill. Lagging causes the arrival of the recharge pulse to be delayed from its introduction at the land surface to its arrival at the bottom of the fill. Dampening causes a reduction in the overall range of recharge values (high minus low) due to uptake and subsequent release of recharge inflow into the soil's pore water. Lagging and dampening both increase with increasing thicknesses of fill. These effects on the timing of recharge will impact the arrival of flow to the top of the slice model, and ultimately the arrival of baseflow to the steams bordering the study area.

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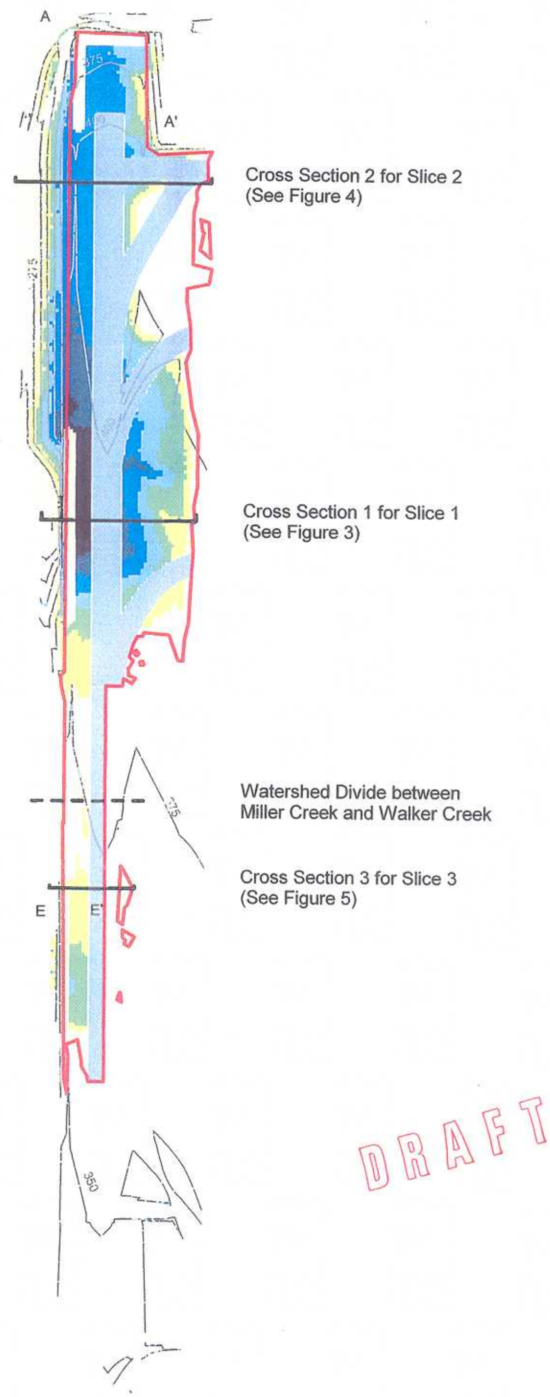

Depth of Fill (feet)

- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 140
- 141 - 160

Area to be Modeled by Hydrus and Slice

Impervious Area

As-Built Elevation Contours (25 ft interval)

N

0 1000 Feet

1:12000

Figure 1

SeaTac Third Runway

Site Features for Hydrus-Slice Modeling

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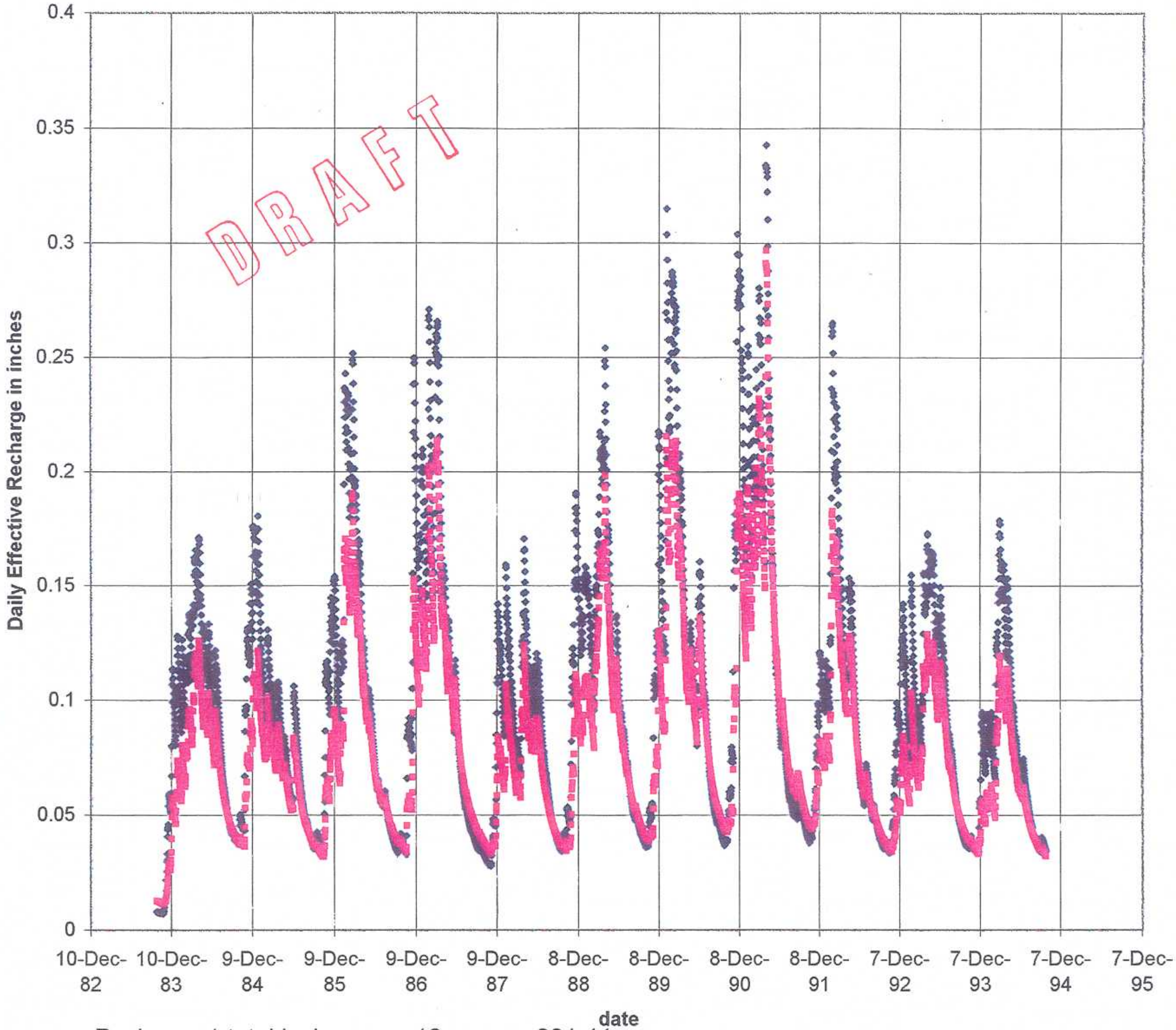
k:/pony/seatac_ii/3rdrunway_depthoffill/3rdrunway_010511.apr (figure 1), 6/22/01

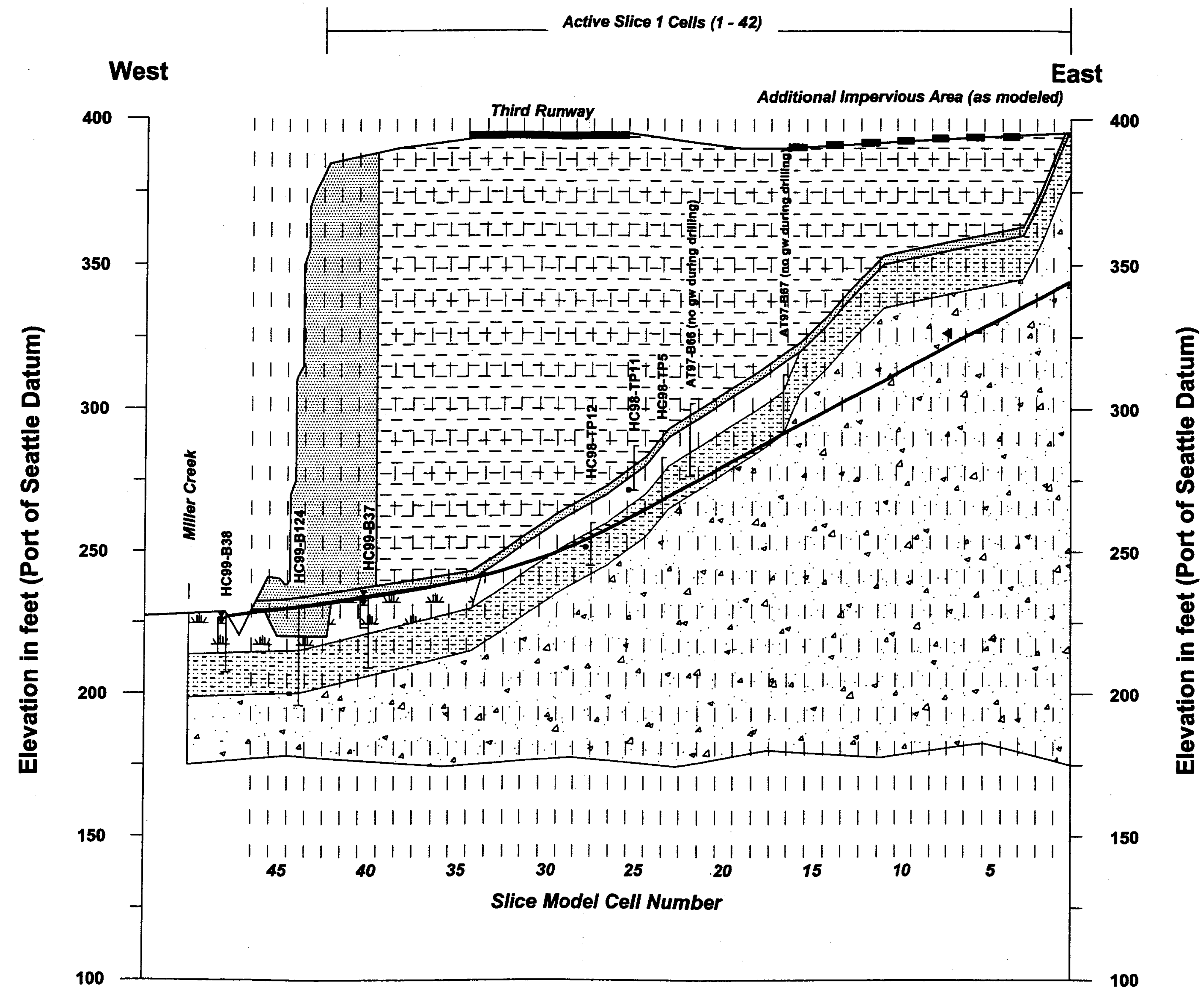
Figure 2
Comparison of Effective Recharge Estimates
For Miller Creek



Recharge 1 total inches over 10 years = 331.44

Recharge 2 total inches over 10 years = 407.48

Difference = 18.7% ((R2-R1)/R2)



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LEGEND

- Groundwater Elevation
- Groundwater Seepage Elevation
- Conceptual Water Table
- Fill
- Qvr - Vashon Recessional
- Qvt - Vashon Till
- Qva - Vashon Advance

Horizontal Scale in Feet: 0 100 200

Vertical Scale in Feet: 0 25 50

FIGURE 3
Simplified Cross Section for Slice 1

SeaTac Third Runway
Embankment Fill Modeling
JE0105, Runway-Section2.dwg, 06/01

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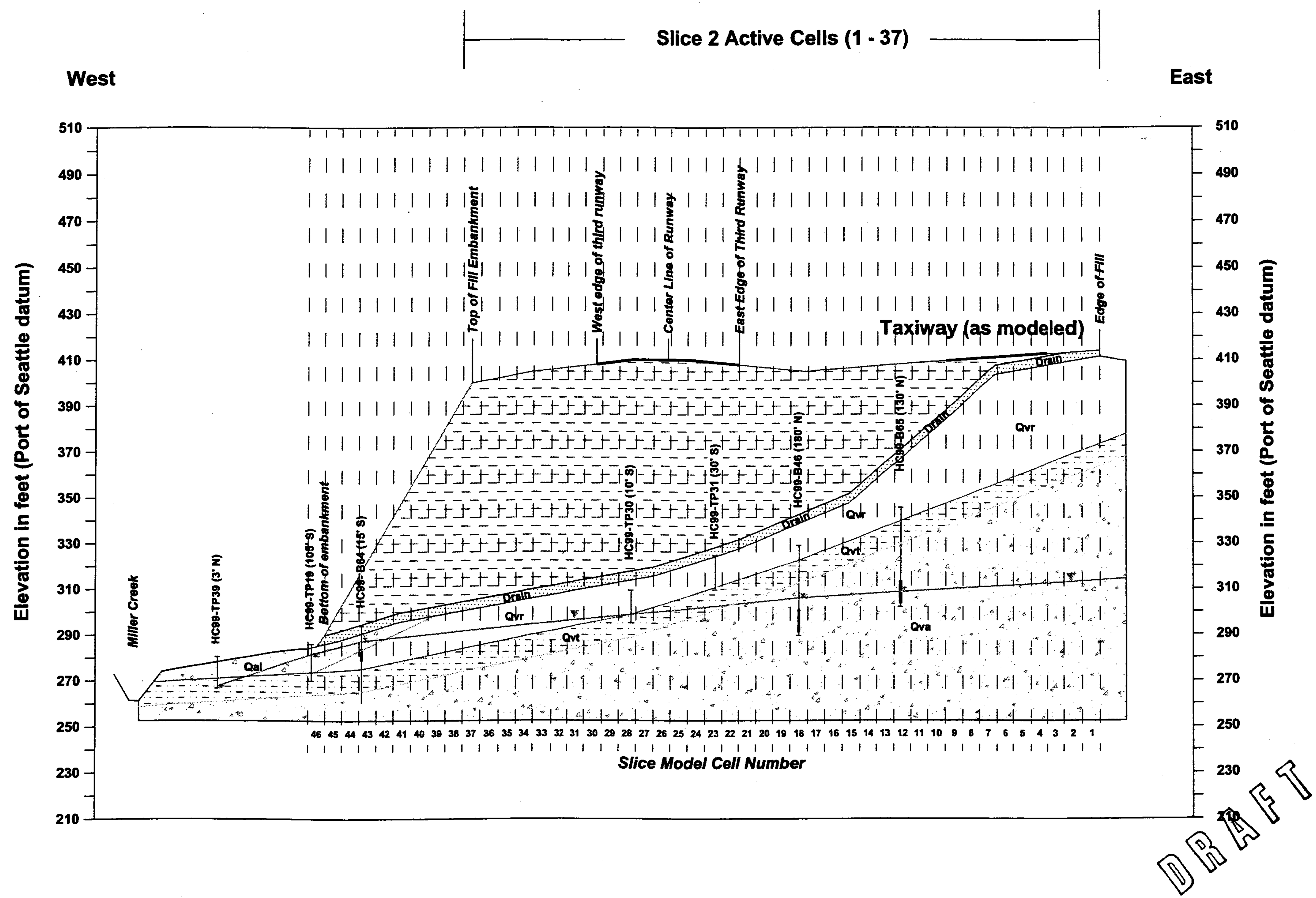

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LEGEND

FIGURE 4
Simplified Cross Section for Slice 2

SeaTac Third Runway
Embankment Fill Modeling
JC0105, Runway-Section2.dwg, 06/01

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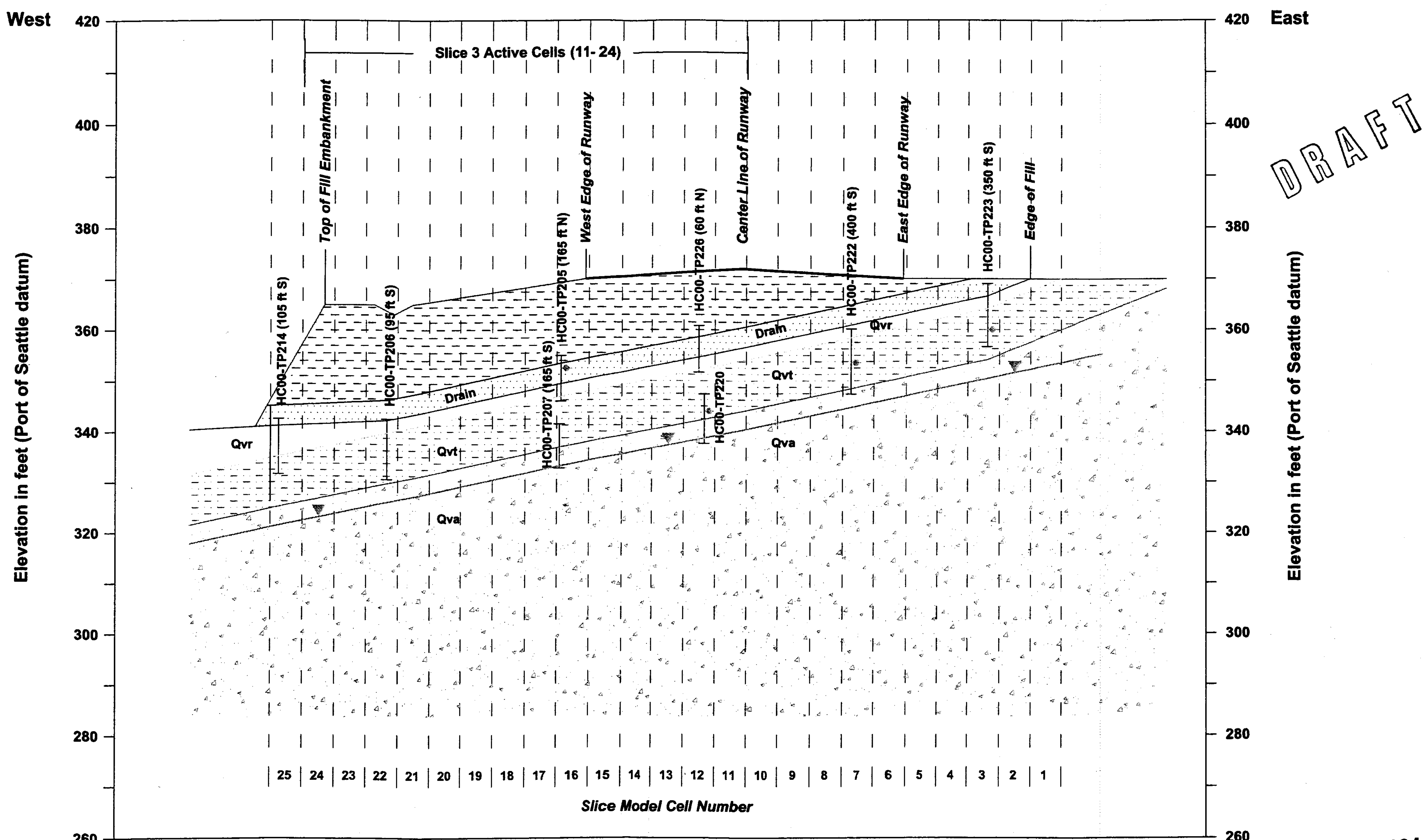

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LEGEND

- Groundwater Elevation
- Groundwater Seepage Elevation
- Conceptual Water Table
- Fill
- Qvr - Vashon Recessional
- Qvt - Vashon Till
- Qva - Vashon Advance

Horizontal Scale in Feet: 0, 40, 80
Vertical Scale in Feet: 0, 10, 20

FIGURE 5
Simplified Cross Section for Slice 3

SeaTac Third Runway
Embankment Fill Modeling
JED105, Runway-Section3.dwg, 06/01

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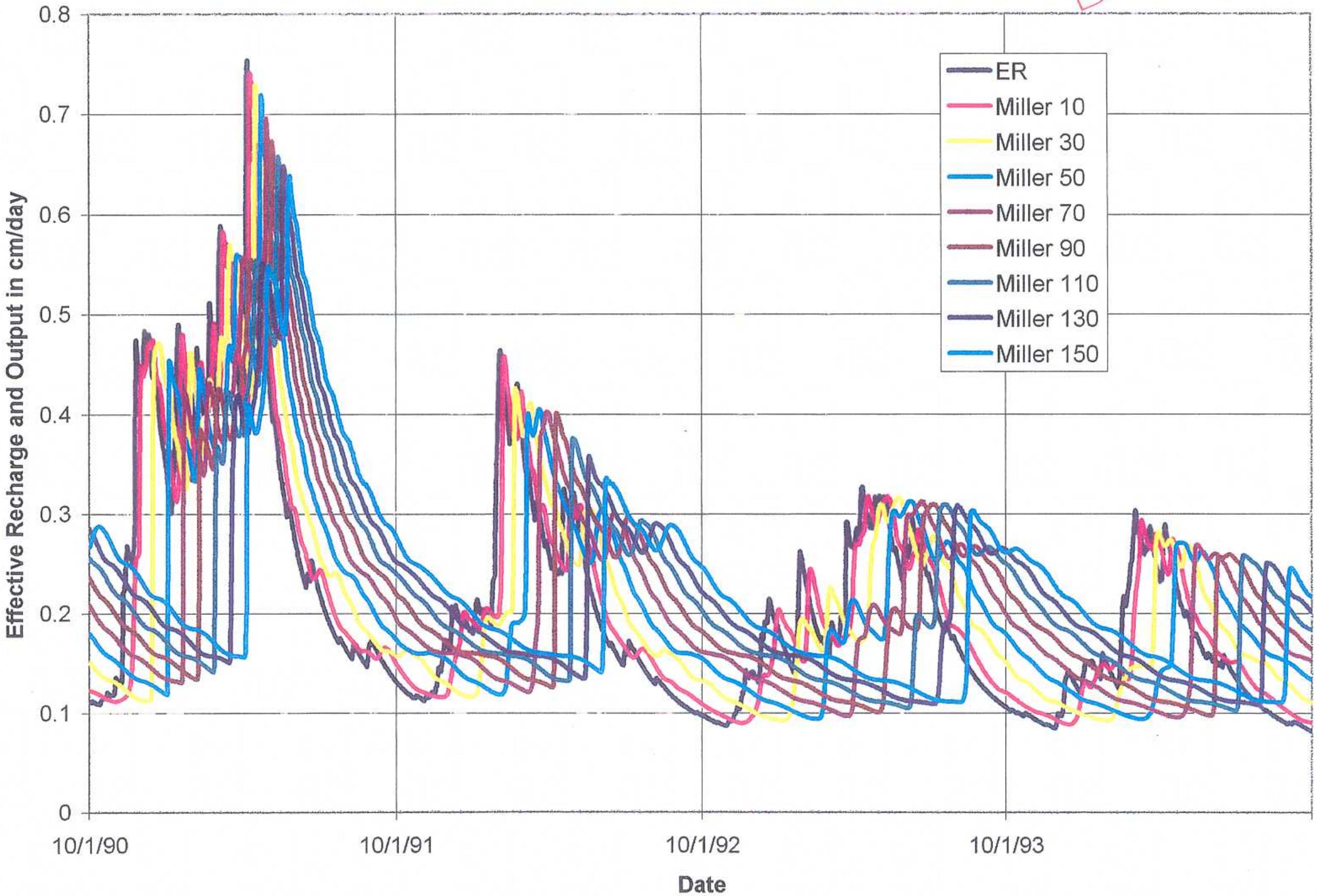
Figure 6
Miller Creek Hydrus Input and Output
(Oct 1, 1990 - Sep 30, 1994)



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