RESPONSE TO COMMENTS ON THURSTON COUNTY MDNS FOR MAYTOWN AGGREGATES

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Signature

This report was prepared by Charles T. Ellingson, licensed hydrogeologist.
RESPONSE TO COMMENTS ON THURSTON COUNTY MDNS FOR MAYTOWN AGGREGATES

This report responds to groundwater-related comments received by Thurston County in response to its MDNS for Maytown aggregates. The County published the MDNS in early April 2004 and received comments from agencies, environmental groups, and citizens. The County then requested that we respond to some of those comments, and summarized them for us in a letter dated April 15, 2004. The results of that analysis are summarized below and explained in greater detail thereafter.

Summary of July 2002 Hydrogeologic Analysis Findings

Pacific Groundwater Group prepared a Hydrogeologic Report for Maytown Aggregates in July 2002. See Appendix A to the Environmental Checklist. That analysis concluded:

- Groundwater and surface water are closely linked, with surface waters of Wetland A and Beaver Creek being at least partly dependent on groundwater discharges.
- The expected post mining condition within pit lakes includes a relatively low permeability “skin” composed of fine sediments that remain as the sand and gravel is extracted. The skin should be augmented during reclamation, particularly on the side slopes of the lakes.
- The creation of open waters excavated below the water table will create a “lake effect”, which, if not mitigated, is expected to reduce groundwater levels upgradient of the lakes, and increase groundwater levels downgradient of the lakes. The open water will also cause evaporation to increase. The evaporation and lake effects are expected to cause an average water level decline at Wetland A (finger 4) of about 1 foot if not mitigated; effects on finger 3 of Wetland A are expected to be about 0.7 feet; and at finger 1 of Wetland A the effect is near zero. Mitigation by augmenting the lakebed skin during reclamation could reduce, eliminate, or even reverse the lake effect, depending on the extent of augmentation.
- If water level monitoring and hydrogeologic analysis indicate that mining is adversely affecting the water level in Wetland A or the Creeks, mitigation by augmenting lakebed skins should be included as part of reclamation.

Summary of April 2004 Hydrogeologic Analysis Findings

The current work provides greater detail, but largely confirms our findings reported with the 2002 SEPA checklist. To provide a most realistic scenario of conditions during mining, we reran the steady-state model with two new scenarios: one assuming that Lakes 3 and 4 (the lakes with the largest north south dimension near Wetland A), were open and unclaimed; and one

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1 The term “lakebed” as used in these documents includes the bottom and sloping sides of the pit lakes. Natural sealing will be greatest on the bottom, whereas reclamation efforts will likely focus on the shore and sloping side walls.
assuming Lakes 6 and 7 (the largest east-west dimension near Wetland A), were open and unreclaimed. We also report on field measurements of current seasonal water level fluctuations and compare that to transient model predictions of the potential effect of the mining operation on these seasonal fluctuations. The results indicate:

- Fluctuations in groundwater levels have been documented to exceed 8 feet in some locations between 2002 and 2004, and the groundwater/surface water elevation at Wetland A (finger 4) has varied by about 4 feet in that same period.
- During the two-year period of record, the shoreline (water's edge) of Wetland A (finger 4) has migrated at least 30 feet between lowest and highest measured stages. At higher stages the water laps against the base of the steep bank demarking the transition from oak woodland to open water wetland, and at lower stages the water's edge occurs on the flatter wetland floor.
- The mining plan calls for reclamation of older pits as new ones are developed (progressive reclamation). If two pits remain unreclaimed and others are yet to be excavated or are fully mitigated, the average water level decline at Wetland A (finger 4) is expected to be less than 0.6 feet. The effect varies greatly depending on which two pits are assumed to be operational (0.6 feet is expected to be the worst two-pit case).
- While the lake effect causes a steady change in water level, seasonal changes will also occur as a result of changes in the timing and magnitude of groundwater recharge. This effect is directly proportional to the amount of open water, and will therefore increase slowly as the mine develops. If all eight lakes are developed and unmitigated, the expected seasonal effects (lake effect plus evaporation effect) are such that the water level change at Wetland A (finger 4) is about 1.3 feet in July and August, and about 0.8 feet in the winter months. Note those values bracket the average water level change cited previously.
- Because the seasonal open-water effects occur before the natural low-water season (typically fall), the mining effects will not translate to an equal increase in total seasonal water level fluctuation, but water levels would be expected to decline earlier in the season than under natural conditions.
- The seasonal groundwater analyses confirmed that augmenting the lakebed skin during reclamation will reduce, eliminate, or even reverse the lake effect, depending on the extent of augmentation.
- The amount of evaporation increase (reduced groundwater recharge) would also be reduced by decrease in the open water surface during the reclamation/augmentation discussed above; however, only complete elimination of the open water would completely eliminate the evaporation increase. Mitigation through lakebed augmentation can also be used to dampen the effects of evaporation increases by distributing the effects in ways that minimize environmental impacts. For instance, water level changes could be spread-out to minimize the effects at any one location, or arranged to eliminate effects at a particularly sensitive location.
- Groundwater and surface water monitoring should be continued during this pre-mining "background" period to document hydrologic variability under existing conditions. Identification of mining effects will require comparison of the "background" and "foreground" data sets. This comparison must also consider many factors apart from mining that are naturally variable, and are likely to differ between the "background" and "foreground" data sets (antecedent precipitation, temperature, water use, beaver activity). It is, therefore, not realistic to expect confident isolation and identification of small mining
effects from the naturally variable hydrology. We therefore recommend that ecologists identify changes that are significant for ecologic receptors in Wetland A and Beaver Creek, and that the monitoring plan focus on identifying only that degree of change. Our analysis indicates that impacts to properly constructed off-site wells will not affect their operation; we therefore recommend that the threshold of significance focus on environmental receptors.

County Comments

Comments 1 and 2 (of 5) are repeated below:

1. The State Department of Fish and Wildlife commented that the Olympic Mudminnow, a State Sensitive species, could inhabit portions of the overall ownership and was not included in the Habitat Management Plan. Please provide an analysis of this finding in relation to the subject property and the proposed mining activity.

2. Please provide additional clarification and analysis of possible impacts and mitigation measures in the hydrology of Wetland A and the surface water systems in relation to Howellia and the Oregon Spotted Frog and the proposed mining operation. The details of the analysis shall include a monitoring plan in partnership with the State of Washington Department of Fish and Wildlife (WDFW) that includes monitoring of the water levels and water temperatures as recommended by WDFW.

April 2004 Update to Hydrogeologic Analysis

Pacific Groundwater Group’s role in the project is to describe groundwater and mining effects on groundwater. Because Beaver Creek, Allen Creek, and Wetland A are dependent on groundwater, we have also analyzed water levels and flows in those surface water features. PGG’s role in addressing the two comments above is to describe current groundwater level fluctuations and to refine estimates of groundwater level changes that could result from mining. The potential impact of the water level changes reported herein on species of concern should be interpreted by your ecologic consultant to provide a complete response to the comments.

The following subsections provide additional field data from continued “background” monitoring in the 20 months since you submitted the SEPA Checklist in August 2002, and the following two additional modeling exercises:

1. Analysis of conditions during gravel mine operation when only two pit lakes are open (not reclaimed) at any one time.

2. Analysis of seasonal groundwater level variations that result from conversion of pasture/forest lands (evapotranspiration) to open water (evaporation).

Because the State granted certificated water rights for use of groundwater from wells, the State has already recognized the effects of that water use, and they therefore have not been included in the modeling exercises. Our analysis of that use is included in the July 2002 report, and is based on a calculation that consumption of 21 gallons per minute of water for washing will result in less than 0.1 feet of drawdown 1000 feet away.
The last section of this report describes how existing and additional water level and water quality data can be generated and interpreted to identify mining effects.

**New Field Data**

Groundwater and surface water levels, and surface water flow measurements, have been collected at the numerous onsite wells and surface water stations (Figure 1) periodically since summer 2002, including up to four measurements through the winter of 2003-2004. Tables 1 and 2 present the data, and the water elevation data are graphed on Figure 2. Based on these new data, the description of groundwater flow and groundwater / surface water relationships in our July 2002 report (*Hydrogeologic Analysis for Maytown Aggregates, Thurston County, Washington*) remains accurate. These new data complement the data set available at that time.

The water level hydrographs of Figure 2 indicate that the relationship between water at the different stations remains similar throughout the seasons. This is indicated by the fact that the hydrographs are roughly parallel. Exceptions to this trend consist of PP04 during 2004, and wetland station Wetland A1 that is plotted with the groundwater data to provide a means of assessing the groundwater / surface water relationship. The reason that the water level in PP04 fell more than the other wells prior to April 2004 is not known; however, that well does have a pump installed and could have been used prior to the water level measurement. The hydrograph of Wetland A1 does not show the seasonal high value of February 4, 2004 as distinctly as the groundwater stations do. This is typical for surface water stations at the downgradient end of a groundwater flow field, and is caused by fact that for a given amount of rainfall, groundwater levels typically rise more than surface water levels.

Data indicate that the average groundwater level fluctuation on the site between 2002 and 2004 was about 6 feet. The largest fluctuations were greater than 8 feet, occurring at stations PP04, MT-10, and MT-11, which, as expected, occupy upgradient locations on the property. The minimum fluctuation was less than 4 feet for those sites that were visited frequently, which occurred at downgradient station PP10. The water level at station Wetland A1 fluctuated about 4 feet.

In addition to the water level measurements, observations were made on the location of the shoreline of the open-water wetland at station Wetland A1. The transition between the oak forest and open water wetland is a steep bank on the order of 5 feet high. Station Wetland A1 is a surveyed stage gage and piezometer located a few feet out in the wetland from the bottom of the bank. The piezometer was added to the original stage gage to allow tracking of water levels as the shoreline recedes past the stage gage during low water periods. During the two-year period of record, the stage has varied about 4 feet and the shoreline (water’s edge) has varied at least 30 feet between lowest and highest measured stages. At higher stages the water laps against the base of the steep bank and at lower stages the water’s edge occurs on the flatter wetland floor.

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2 The modeling analyses discussed in subsequent sections assume that Wetland A is purely groundwater, and thus do not incorporate the moderating influences of the surface water body. The modeling analyses may therefore over-predict water level changes in the surface waters.

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Surface water discharge measurements have also been made at several times at the two Beaver Creek Stations (BC1, BC2), and one Allen Creek Station (DL1). Table 2 presents the surface water level and flow data.

The discharge at DL-1 has been measured twice at the southernmost culvert under Tilley Road. This was thought to be the only culvert under Tilley Road until, on April 8, 2004, two additional culverts were observed downstream (north) of where the discharge measurements were taken. These culverts had been obscured by weeds and muddy high water. Therefore, some of the flow may not have been measured during the previous measurements. During the dry season and late in the winter, flow ceases in this ditch or becomes so slow it cannot be measured with a propeller meter.

Discharge at station BC2, where Beaver Creek enters the property on the east, has varied from at least 0.32 to 5.21 cubic feet per second (cfs) during the period of record, with the minimum and maximum occurring during October 2002, and February 2004, respectively. The February 2004 measurement was after a period of significant rainfall, but not during a period of surface runoff during or directly after a rainfall period – thus, we interpret this measurement to represent winter baseflow or baseflow plus interflow (shallow groundwater flow that discharges to streams soon after rainfall stops). Not surprisingly, the times of minimum and maximum streamflow are also the times of minimum and maximum groundwater elevation. Flow in Beaver Creek as it exits the property at BC1 has varied from at least 0.25 to 24.32 cfs over the two-year period of record, with the minimum and maximum occurring at the same times as at BC2.

Comparing the influent and exfluent flow rates shows that Beaver Creek does not gain water across the site during low flow periods and thus that substantial groundwater discharge to the creek is minimal during those periods, although some transfers between the surface water and groundwater likely occur within the site even during low flow periods. At high stage, significant flow accumulates as the stream traverses the property. In the case of the February 2004 measurement, that flow increase represents discharge of groundwater and interflow to the creek, and streamflows from the till-mantled upland south of the property where interflow may be a prominent component of storm hydrographs.

Analysis of a Partially-Developed, or Partially-Reclaimed, Site

The mining plan involves reclamation of completed pits as subsequent pits are used to extract gravel. Therefore all eight pits will not be open and unreclaimed at once. An analysis was therefore performed to simulate the water level changes when two pits are open, and the others are either not excavated or fully mitigated with respect to the lake effect. Our analysis reported in the 2002 SEPA checklist analyzed all eight pits in three scenarios: as they are expected to naturally occur after all excavation is complete without mitigation, and under two mitigation schemes wherein extra material is placed on the side slopes during reclamation, but that analysis did not evaluate fewer than eight pits.

Six model runs were performed to simulate the partially-excavated and partially-reclaimed-and-mitigated site. The runs are organized into two groups, one evaluating the lake effect when pits 3 and 4 are open and unreclaimed, and the other evaluating pits 6 and 7 in a similar condition. Pits 3 and 4 comprise a set with a large north-south length that is close to Wetland A. Pits 6 and
7 comprise a set that has a large east-west length and is also close to Wetland A. Similar to our prior model analysis, each condition was modeled for the expected non-mitigated hydraulic properties of the pit lakebed (0.7 feet thick with a permeability of 0.2 ft/day) and for two conditions where mitigation is used to reduce the conductance of the lakebed. In “mitigation example 1” the permeability of the lakebed was reduced to 0.03 ft/day, and in “mitigation example 2” the thickness of the 0.03-ft/day permeability lakebed was increased to 4 feet (thus further decreasing the overall conductance of the lakebed). Under all six model scenarios, the remaining six lakes (not simulated by the model) were assumed to have no significant effect on the groundwater flow system. This either represents a condition where the lakes had not yet been excavated or where mitigation measures made their influence on the flow system small. Also similar to our prior model analysis, all simulations were performed in steady-state mode, which simulates long-term average conditions.

Table 3 summarizes the results of the two-pit model analyses alongside the prior set of three model analyses where all eight proposed lakes were included in the simulation. Figures 3 through 5 compare both two-lake simulations for each mitigation condition: non-mitigated, mitigation example 1, and mitigation example 2. Mitigation here refers to the intentional addition of relatively low permeability soils on the lakebed.

The modeling exercises predict that water level changes with only two pits open is substantially reduced compared to having eight pits open. Also, the effects of decreasing lakebed conductance first reduces the lake effect, and if carried further, can reverse the effect, as shown previously for the eight-pit modeling exercise. With pits 3 and 4 open and unmitigated, groundwater levels are expected to decline not more than 0.5 feet in the upgradient areas (Table 3 and Figure 3) compared to the 1.2 to 1.8 feet in the eight-pit example, and to cause groundwater mounding that is imperceptible in the downgradient areas. At the location of Wetland A1, the expected lake effect is at the lower end of the range for upgradient areas, being between 0.1 and 0.2 feet of water level decline. As for the eight-pit cases, decreasing lakebed conductance is likely to first reduce the lake effect further, and if carried further, could reverse it.

Modeling of pits 6 and 7 indicated somewhat greater upgradient lake effect (~0.6 feet), and the details of the geographic distribution of effects are such that the effect at Wetland A1 is near the maximum of the upgradient range. For the expected condition, the water level decline there is about 0.6 feet (Table 3 and Figure 3).

Analysis of Seasonality

Two additional model simulations were performed to address concerns about the seasonality of hydrologic effects. Prior model analyses were performed in steady-state mode, which means that all stresses on the groundwater flow system were held constant throughout the year. In the prior case, an annual average of the change in evapotranspiration (~0.15 cfs) was simulated for the new pit lakes. However, in reality, evapotranspiration from the lakes will be greatest during summer months and smallest during winter months and the difference between evapotranspiration from pasture/forest and evaporation from a lake is also greatest in summer. The two additional simulations were run in transient mode, which allows the difference in evapotranspiration to vary over time. Monthly values of change in evapotranspiration were estimated by examination of the HSPF model output prepared for the July 2002 report and

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resulted in a recharge decrease (evapotranspiration increase) of 0.54 in/month in July to a recharge increase of 0.06 in/month in March. The model provided transient predictions of change in groundwater levels over an annual cycle at four selected wetland locations (Figure 1).

The two transient simulations were selected to represent the endpoints of the spectrum of lakebed hydraulic properties simulated previously. Both simulations assumed all eight lakes existed. The first transient run represented the non-mitigated (expected) lakebed properties and the second transient run represented the least conductive lakebed (mitigation example 2). Some difficulty was encountered when running transient simulations on the prior model, as instabilities associated with dry cells caused unusable results. In order to correct this situation, PGG used the following two-stage approach based on the principal of superposition:

1. The existing multi-layer model was run in steady-state mode with lake excavations for the two selected model scenarios. The lakes were represented similar to the prior model with very high internal permeability values and “slurry wall” boundaries to represent lakebeds; however, the change in recharge associated with evaporation change was not simulated in these steady state runs. The results thus represented the “lake effect” only.

2. PGG developed a single-layer model to estimate the transient effects of seasonally variable recharge (evaporation loss from the lakes). The single layer model includes all the hydrologic features of the prior model (streams, natural recharge, constant head boundaries), but is more stable since single layer models are typically stable even with the occurrence of dry cells. Model transmissivity (hydraulic conductivity times thickness) was equal to the sum of transmissivity for all model layers in the prior model. When run for the pre-mining condition, the single-layer model showed very similar results to the prior model. The single-layer model was run with all eight lakes simulated over 12 1-month stress periods (each with an average monthly value of change in evapotranspiration). It was run multiple times until a “cyclic steady state” was predicted, meaning that the annual cycle of groundwater level variation did not change significantly from year to year. These model results represent change in groundwater level associated with change in recharge only (no lake effect).

In order to estimate the change in groundwater level from both the lake effect and the seasonal change in recharge, the model predictions were superimposed. Figures 6 and 7 present model predictions of change in groundwater level that result from both the lake effect and recharge difference over an one-year cycle and Table 4 compares the ranges of water-level change predicted for the prior steady-state simulation versus the two transient simulations. The stair-step nature of the hydrographs in Figures 6 and 7 is a result of the monthly time steps and is not expected in nature.

The analysis indicates that maximum groundwater level change (from current conditions) near Wetland A and Beaver Creek will occur in July and August, and that the minimum will occur in the winter months (Figures 6 and 7). Minimum groundwater elevations occur generally in the fall, and thus the time of maximum mining effect occurs earlier in the season than the minimum groundwater levels. Thus, mining effects will not translate into an equal increase in the total water level variation measured in the field, but water levels would likely decline earlier in the summer than under present conditions. Unmitigated winter and summer water level changes for this eight-pit example are predicted to be 0.8 and 1.3 feet; 0.45 and 0.9 feet; and 0.1 and -0.1 feet at locations Wetland A1, Wetland A2, and Wetland A3, respectively (Table 4). These results

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bracket and agree with the steady-state analyses presented in our July 2002 report, although the points at which the results are evaluated are not the same in all cases.

Note that the average water level change for any one location is quite sensitive to decreasing the lakebed conductance, but the seasonality is consistent regardless of the assumed lakebed conductance. That relationship occurs because reduction in lakebed conductance changes (reduces, then reverses) the lake effect, but not the effects of seasonal changes in evapotranspiration. Changes in evaporation would, however, be reduced by the extent that the reclamation reduces the open water surface area; however, only complete elimination of the open water would completely eliminate the evaporation increase. Mitigation through lakebed augmentation can also be used to dampen the effects of evaporation increases by distributing the effects in ways that minimize environmental impacts. For instance, water level changes could be spread-out to minimize the effects at any one location, or arranged to eliminate effects at a particularly sensitive location.

The seasonality of water level changes is primarily a function of the amount of open water and would therefore build slowly over the course of the 20-year mine plan as open water is created. The results described immediately above assume all eight-pits are open.

**Continued Hydrologic Monitoring**

This subsection discusses the frequency of additional data collection, which is one element of a hydrologic monitoring program. A Groundwater Monitoring Plan was included as Appendix F to our July 2002 report.

The existing Groundwater Monitoring Plan stipulates that water levels be measured six times a year starting with issuance of the mining permit, and to be continued throughout the operational period of the mine. Our only recommended modification to that schedule would be that if the mining permit is delayed, you begin collecting data in accordance with the Groundwater Monitoring Plan and Habitat Management Plan at this time. We currently have five or six measurements of water level and flow at the key locations over a period of almost two years. Additional data in this “background” period will strengthen the monitoring plan by documenting hydrologic variations prior to mining. It will therefore also allow us to more easily identify changes to the hydrology during mining, as explained further below.

A “background” data set is typically defined as all the hydrologic measurements collected during a period before mining effects are expected. There are no hard and fast rules about how many measurements should be in the background data set; however, the more data that are included in the background data set, the better will be our ability to identify mining effects in the “foreground” (period of mining). To include as much data as possible in the background data set, we recommend that the background period include all data prior to mining below the water table south of the railroad tracks. This would allow the background period to include the time that pits 1 and 2 are being mined north of the railroad tracks. Pits 1 and 2 are far enough from
the critical hydrologic resources (mostly wetland A) to preclude significant hydrologic impacts there.

Whether or not mining effects are significant for biota in Wetland A should be left to the Habitat Management Plan. The hydrogeologist's contribution to that effort can include interpretation of foreground data to identify mining effects, without regard for their significance. Identification of mining effects should consist of comparing the background and foreground data sets, with careful consideration of the statistical distribution of hydrologic data, antecedent conditions (rainfall, temperature etc), and possibly statistical significance. The hydrology of the site will be influenced by hydrologic variables acting on local (mining, beavers, groundwater use), regional, and global scales (including global warming) that will not be the same during the background and foreground periods. Thus, to identify mining effects, the comparison must include corrections for all variables except mining – and even then the identification of small effects will always be subject to substantial uncertainty. Larger changes are more easily ascribed to a particular variable. To allow efficient data analysis, we recommend that the Habitat Management Plan identify a threshold water level change that is deemed significant.

Methods of interpreting the foreground data were broadly outlined in the Groundwater Monitoring Plan. The details of the analytical method should be left to the discretion of the hydrogeologist. Such methods may include trend analysis, statistical hypothesis testing, reference to existing long-term data sets in Thurston County, and use of antecedent precipitation indices. Department of Ecology hydrologic basin plans and solid waste monitoring regulations provide examples of some of these processes.

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3 Monitoring station MT-10 may require a shorter background period because of its close proximity to pits 1 and 2.
Table 1. Groundwater Level Measurements

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<td></td>
<td>204.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>06/11/02</td>
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<td>213.22</td>
</tr>
<tr>
<td>06/19/02</td>
<td>204.02</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>06/20/02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>209.06</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>10/03/02</td>
<td>202.37</td>
<td></td>
<td>202.17</td>
<td></td>
<td>205.65</td>
<td></td>
<td>210.01</td>
<td></td>
<td>210.19</td>
<td></td>
<td>209.57</td>
<td></td>
<td>211.47</td>
</tr>
<tr>
<td>12/01/03</td>
<td>205.90</td>
<td></td>
<td>214.02</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/18/03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>206.29</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
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<td>213.76</td>
</tr>
<tr>
<td>02/04/04</td>
<td>206.97</td>
<td></td>
<td></td>
<td>207.73</td>
<td></td>
<td>216.22</td>
<td></td>
<td>212.81</td>
<td></td>
<td>217.52</td>
<td></td>
<td>216.44</td>
<td></td>
</tr>
<tr>
<td>04/08/04</td>
<td>204.85</td>
<td>205.93</td>
<td>204.98</td>
<td></td>
<td>211.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values are groundwater elevations in feet above mean sea level (NGVD29)
Table 2. Surface Water Measurements

<table>
<thead>
<tr>
<th>Station Name</th>
<th>Date</th>
<th>Stage (ft)</th>
<th>Discharge (cfs)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC1</td>
<td>06/11/02</td>
<td>8.65</td>
<td>2.77</td>
<td>Top of concrete bridge abutment about 6&quot; above road level, downstream side, middle of bridge.</td>
</tr>
<tr>
<td>BC1</td>
<td>10/03/02</td>
<td>6.80</td>
<td>0.25</td>
<td>Low velocities, low accuracy.</td>
</tr>
<tr>
<td>BC1</td>
<td>12/19/03</td>
<td>7.56</td>
<td>13.49</td>
<td></td>
</tr>
<tr>
<td>BC1</td>
<td>02/04/04</td>
<td>7.38</td>
<td>24.32</td>
<td></td>
</tr>
<tr>
<td>BC1</td>
<td>04/08/04</td>
<td>8.12</td>
<td>4.70</td>
<td></td>
</tr>
<tr>
<td>BC2</td>
<td>06/11/02</td>
<td>2.51</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>BC2</td>
<td>10/03/02</td>
<td>1.88</td>
<td>2.58</td>
<td></td>
</tr>
<tr>
<td>BC2</td>
<td>02/04/04</td>
<td>1.75</td>
<td>5.21</td>
<td></td>
</tr>
<tr>
<td>BC2</td>
<td>04/08/04</td>
<td>2.24</td>
<td>1.35</td>
<td></td>
</tr>
<tr>
<td>DL1</td>
<td>12/19/03</td>
<td></td>
<td>1.38</td>
<td>No place to measure stage</td>
</tr>
<tr>
<td>DL1</td>
<td>02/04/04</td>
<td></td>
<td>2.44</td>
<td>No place to measure stage</td>
</tr>
<tr>
<td>WETA1</td>
<td>06/11/02</td>
<td>1.46</td>
<td></td>
<td>Near well PP08, Enameded staff gage on 2 by 4 clamped to steel fence post in wetland.</td>
</tr>
<tr>
<td>WETA1</td>
<td>06/13/02</td>
<td>1.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WETA1</td>
<td>06/19/02</td>
<td>1.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WETA1</td>
<td>10/04/02</td>
<td>-1.58</td>
<td></td>
<td>Installed 1-inch, slotted piezometer to measure water level when it drops below staff gage base</td>
</tr>
<tr>
<td>WETA1</td>
<td>12/01/03</td>
<td>2.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WETA1</td>
<td>12/19/03</td>
<td>2.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WETA1</td>
<td>02/04/04</td>
<td>2.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WETA1</td>
<td>04/08/04</td>
<td>2.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC1</td>
<td>06/19/02</td>
<td>8.64</td>
<td></td>
<td>Stage only. Hard to read accurately +0.02 due to wind.</td>
</tr>
<tr>
<td>BC1</td>
<td>12/01/03</td>
<td>7.40</td>
<td></td>
<td>Stage only</td>
</tr>
<tr>
<td>BC2</td>
<td>06/03/02</td>
<td>2.49</td>
<td></td>
<td>Stage only. MP is top of upstream steel culvert</td>
</tr>
<tr>
<td>BC2</td>
<td>06/19/02</td>
<td>2.46</td>
<td></td>
<td>Stage only</td>
</tr>
<tr>
<td>BC2</td>
<td>12/01/03</td>
<td>1.68</td>
<td></td>
<td>Stage only</td>
</tr>
</tbody>
</table>

Stages are surface water elevations in feet above mean sea level (NGVD29)
<table>
<thead>
<tr>
<th>Simulation Number</th>
<th>Scenario</th>
<th>Model run</th>
<th>Estimated Time (d)</th>
<th>Take-up Time (Hrs, minutes)</th>
<th>Upgradient</th>
<th>Downgradient</th>
<th>Change in Groundwater Level Compared to Current Condition Mode</th>
<th>Change in Groundwater Level Compared to Current Condition Mode</th>
<th>To Beaver Creek between BC1 and BC2</th>
<th>Through Deep Take Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Calibrated Current Condition</td>
<td>N/A</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>2</td>
<td>Expected Lakebed Conductance</td>
<td>All</td>
<td>MTCurslerHighKwet-7-8b</td>
<td>0.7</td>
<td>0.2</td>
<td>-1.2 to -1.8</td>
<td>0 to 0.2</td>
<td>-0.22</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Expected Lakebed Conductance</td>
<td>3,4</td>
<td>Run8b-Pits34</td>
<td>0.7</td>
<td>0.2</td>
<td>-0.15 to -0.5</td>
<td>-0.01 to 0.03</td>
<td>-0.02</td>
<td>-0.01</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Expected Lakebed Conductance</td>
<td>6,7</td>
<td>Run8b-Pits87</td>
<td>0.7</td>
<td>0.2</td>
<td>-0.6 to -0.6</td>
<td>0.01 to 0.06</td>
<td>-0.09</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Mitigation Example 1</td>
<td>All</td>
<td>MTCurslerHighKwet-7-8c</td>
<td>0.7</td>
<td>0.03</td>
<td>-0.4 to -0.8</td>
<td>0 to 0.2</td>
<td>-0.12</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Mitigation Example 1</td>
<td>3,4</td>
<td>Run8c-Pits34</td>
<td>0.7</td>
<td>0.03</td>
<td>0 to -0.1</td>
<td>-0.02 to 0.02</td>
<td>-0.02</td>
<td>-0.01</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Mitigation Example 1</td>
<td>6,7</td>
<td>Run8c-Pits67</td>
<td>0.7</td>
<td>0.03</td>
<td>-0.2 to -0.2</td>
<td>0.02 to -0.1</td>
<td>-0.03</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Mitigation Example 2</td>
<td>All</td>
<td>MTCurslerHighKwet-7-8d</td>
<td>4</td>
<td>0.03</td>
<td>0.8 to 1.4</td>
<td>0 to -0.4</td>
<td>0.12</td>
<td>-0.16</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Mitigation Example 2</td>
<td>3,4</td>
<td>Run8d-Pits34</td>
<td>4</td>
<td>0.03</td>
<td>0.25 to 0.5</td>
<td>0 to -0.15</td>
<td>0.01</td>
<td>-0.03</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Mitigation Example 2</td>
<td>6,7</td>
<td>Run8d-Pits67</td>
<td>4</td>
<td>0.03</td>
<td>0.4 to 0.4</td>
<td>0 to -0.2</td>
<td>0.05</td>
<td>-0.05</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE 1:** Negative value is a decline in water level, positive value is a rise.
Upgradient area is layer 1, and roughly from the eastern end of the eastern finger of wetland A to the northeastern property boundary.
Downgradient area is layer 1, and roughly from the western most finger of wetland A that is attached to Beaver Creek, to the northwest property boundary.

**NOTE 2:** Negative value is a reduction in flow, positive value is an increase.
Table 4 - Modeled Seasonal Water Level Changes

<table>
<thead>
<tr>
<th>Model Simulation</th>
<th>Lakebed Thickness</th>
<th>Lakebed Permeability</th>
<th>Welland A-1</th>
<th>Welland A-2</th>
<th>Welland A-3</th>
<th>Beaver Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steady State Expected Lakebed Conductance</td>
<td>0.7 feet</td>
<td>0.2 ft/day</td>
<td>-1.1</td>
<td>-0.7</td>
<td>-0.02</td>
<td>-0.6</td>
</tr>
<tr>
<td>Transient Expected Lakebed Conductance</td>
<td>0.7 feet</td>
<td>0.2 ft/day</td>
<td>-0.8</td>
<td>-1.3</td>
<td>-0.45</td>
<td>-0.9</td>
</tr>
<tr>
<td>Steady State Mitigation Example 2</td>
<td>4 feet</td>
<td>0.03 ft/day</td>
<td>0.9</td>
<td>0.5</td>
<td>-0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Transient Mitigation Example 2</td>
<td>4 feet</td>
<td>0.03 ft/day</td>
<td>1.05</td>
<td>0.6</td>
<td>0.7</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Notes: All values in feet, unless otherwise specified.

All simulations assume the existence of 8 pit lakes.
PIT LAKES 3 & 4

NOTES:
Values in feet.
Positive numbers indicate water level decline.
Negative numbers indicate water level rise.
Contour interval = 0.1 feet.

FIGURE 3
PREDICTED STEADY-STATE CHANGE IN GROUNDWATER LEVEL UNDER
EXPECTED LAKEBED CONDUCTANCE

PIT LAKES 6 & 7
FIGURE 4
PREDICTED DRAWDOWNS UNDER MITIGATION EXAMPLE 1

NOTES:
Values in feet.
Positive numbers indicate water level decline.
Negative numbers indicate water level rise.
Contour interval = 0.1 feet.
FIGURE 5
PREDICTED DRAWDOWNS UNDER MITIGATION EXAMPLE 2

NOTES:
Values in feet.
Positive numbers indicate water level decline.
Negative numbers indicate water level rise.
Contour interval = 0.1 feet.
FIGURE 6
SEASONAL CHANGE IN GROUNDWATER LEVEL AT SELECTED MONITORING POINTS
EXPECTED (NON-MITIGATED) PIT LAKEBED CONDUCTANCE

All simulations assume the existence of 8 pit lakes.
FIGURE 7
SEASONAL CHANGE IN GROUNDWATER LEVEL AT SELECTED MONITORING POINTS PIT LAKEBED CONDUCTANCE FROM MITIGATION EXAMPLE 2

All simulations assume the existence of 8 pit lakes.
September 26, 2005

Allen & Company, LLC
PO Box 2510
43520 SE North Bend Way
North Bend, WA 98045

Attention: J. M. Allen

Re: MAYTOWN AGGREGATES
REVISED AND EXPANDED ANALYSIS OF HYDROLOGIC EFFECTS FROM MINING, AND PRESENTATION OF A REVISED GROUNDWATER MONITORING PLAN

This letter report provides additional analyses and information on groundwater effects from the referenced gravel mine proposal. The analyses are in part a response to concerns expressed in a June 8, 2004 letter from Tony Kantas of Thurston County to J. Allen of Allen & Company regarding the proposed mine. In that letter, the County expressed concerns that lead it to reconsider the Mitigated Determination of Non-Significance (MDNS) and possibly issue a Determination of Significance (DS). In the same time frame, the County provided us a comment letter from Joel Massmann (of Keta Waters, dated May 18, 2004).

Since that time Pacific Groundwater Group has worked closely with Joel Massmann, other representatives of environmental organizations, and State experts on howellia, Oregon spotted frog, and Olympic mudminnow to develop a common understanding of the risks that mining effects have to the nearby wetland, and the uncertainties in that assessment. The hydrologic assessment used by that technical team included the information in this report. Based on work by the technical team, Allen & Company reached an agreement with the environmental organizations that accommodates the potential wetland effects and uncertainties. A conservation fund was established for use by the environmental organizations as part of that agreement.

The purposes of this report are therefore to document new and revised hydrologic analyses and present a groundwater monitoring plan that has been revised to compliment the conservation agreement for the wetland. Direct response to the County's concerns listed in the Kantas letter of June 8, 2004 are contained in a letter to Tony Kantus from Alison Moss of Dearborn Moss dated September 2005. The responses in that letter are consistent with this technical report and were reviewed and accepted by Pacific Groundwater Group and Charles T. Ellingson, a licensed professional hydrogeologist in the State of Washington.
Model Refinements

In addition to the software correction, the current model reflects refinements and improvements implemented by Pacific Groundwater Group. These refinements consist of:

- Performing sensitivity analysis of model groundwater level predictions to the permeability assigned to lake cells in the model.
- Re-assessing groundwater level changes associated with the lake effect based on increasing the modeled lake “permeability” by a factor of ten.
- Resolving issues with model solver settings for the 3-layer model that now allow it to run in transient mode.
- Re-assessing seasonal groundwater level impacts associated with seasonal changes in evaporation at the lakes using the 3-layer model. Storage coefficient in the lakes was set equal to 0.99.

Because of the software corrections and refinements listed above, the current model supersedes prior versions of the model and provides new estimates of both long-term impacts to groundwater caused by the lake effect, and seasonal impacts to water levels caused by seasonal evaporative losses from the pit lakes.

Field Data Basis for Lake Skins

A literature search, discussion with local mine operators, and evaluation of Maytown boring logs were used to provide a frame of reference for lake skin assumptions used in modeling.

Several scientific articles document the presence of, and effect of, backfilling of gravel pit lakes; however, few document the development of the natural sediment layers that accumulate on pit-lake beds (skins). Most of the available scientific articles were reviewed by Mead³. One article documented the permeability and thickness of natural pit-lake sediment⁴ – this measurement formed the basis for the permeability used in modeling the lake bed skin for the Maytown groundwater model.

Rongey Associates⁵ recent analysis of hydrologic impacts of gravel mining in the Pilchuck Valley indicated that collapse of pit lake side-walls noticeably reduces aquifer permeability.

at the sidewall. This effect would be in addition to any effects of sedimentation. Rongey Associates’ report is discussed later in this letter report.

Pacific Groundwater Group evaluated boring logs from the Maytown site to provide a semi-quantitative basis for assessing how much fine-grained material is likely to be left behind after removing the sand and gravel fractions of the mined deposit. The issue was also discussed with the mine planning company, Sub-Terra Inc. Evaluation of the boring logs suggested that on the order of 10 percent of the mined deposit should be in the silt and clay grain size fractions. Sub-Terra Inc. estimated that the silt and clay fraction was more likely to be about 5 percent of the mined volume. If 5 to 10 percent were spread evenly on the floor and sidewalls of the pit lakes, the silt and clay would form a layer 3 to 7 feet thick. Modeling of the expected, unmitigated, condition assumes an average thickness of 0.7 feet of silty material on the side walls. Some of the remaining fine-grained material will be transported off-site inadvertently with the sand and gravel, some will be retained for reclamation of the pit lake banks, and much of it will be retained in the sedimentation ponds.

**Prediction of Lake Effects on Annual Average Groundwater Elevation**

The improved model was used to calculate average annual water-level effects associated with lake excavation at different stages through the expansion of the mine. Table 1 presents the mine expansion schedule used for model simulation.

The schedule includes eight consecutive “steps” of pit excavation, some of which include excavation of more than one pit-lake. While mining operations may ultimately differ from this expansion schedule, the schedule represents current best estimates of the order of pit-lake excavation. The completion of each of these excavation steps was run in steady-state mode using the refined model. For the steady-state simulations, changes in evaporation due to creation of lakes were modeled with the same average annual difference in evaporation used in previous modeling (0.0012 feet/day). The lake beds were also assumed to have the same properties as previous analyses of the unmitigated condition (an average of 0.7 feet of silt with a permeability of 0.2 feet/day). Figure 1 shows the predicted changes in groundwater levels after 20 years of mine development. This represents the full build-out of the gravel mine and in most cases the maximum impact on groundwater levels. The figure also identifies eight observation points, for which water-level changes predicted at the end of each excavation step are summarized on Table 2. Figure 2 graphs the predictions of water-level changes over time at each observation point and shows that groundwater level changes are predicted to develop slowly over many years.

The time-series trends shown on Figure 2 are based on steady state model runs. The results therefore represent the water-level impacts caused by new pit lakes after lake skins have fully developed and after the groundwater flow system has had sufficient time to fully adjust to the presence of the excavations. Pits will be excavated over time, fines will take time to settle-out, and reclamation (which will add soil to the lake shore and side walls) will occur as each

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6 The first step is based on mining above the water table, and therefore does not result in formation of a pit lake. Steps 2 through 8 include excavation below the water table.
pit is completed. Also, in some cases, the next excavation step may occur before the impacts of the previous excavation step are fully realized. Thus water level effects will approach the steady-state condition over time, and may do so in a variable way. The final (20-year) predictions represent the long-term impact to the groundwater flow system after the skins have completely formed and the aquifer has fully responded to the excavations. We expect that the magnitude of short-term water level changes will be less than the magnitude of steady-state water level changes.

Note that corrected water level change predictions are of a similar magnitude as former predictions, but whereas the former predictions indicated water elevation declines upgradient of the pit lakes, the corrected analyses indicate higher water elevations upgradient of the pit lakes. This change results from Groundwater Vistas’ writing corrected lake skin conductance values to MODFLOW. For instance, the corrected analysis indicates that under the expected, unmitigated condition, groundwater elevation at Finger 4 is likely to rise about 0.1 feet within 5 years of mining, that after about 14 years of mining the groundwater elevation is likely to be about 1.2 feet higher, and that at completion of mining after 20 years, the groundwater elevation will be about 1.1 feet higher than current conditions. The corrected model indicates that groundwater elevations would decline slightly downstream of the pit lakes in the expected, unmitigated, condition. For instance, at location PP-10, groundwater elevation would be expected to decline about 0.1 feet over 20 years.

The results above are based on the expected condition where a fraction of the silt contained in the mined deposit creates a skin of reduced permeability on the lake walls as a result of natural settling and reclamation. The model was also used to simulate the lake effect in an assumed case where no skin formed and no reduction of berm permeability occurred as a result of sloughing (sloughing effects are discussed in the section on a Pilchuck Valley mine below). These assumed conditions define a theoretical worst-case condition with respect to the lake effect; however, we do not consider it to be a realistic scenario. Results assuming “no skin” indicate that groundwater elevation would decline on the upgradient side of the site and increase on the downgradient side of the site. For instance, at Finger 4, water elevation would be expected to decline about 1.9 feet over 20 years. Figure 3 presents these results and is analogous to Figure 1 which was generated for the expected condition. Comparison of these figures shows that the lake effect for the expected condition is opposite in a qualitative sense to the lake effect if no skin formed. The results infer that an effective skin and berm permeability that lies between the expected condition and the “no skin” condition would result in a minimum lake effect.

The water level changes cited above for Finger 4 and other wetland observation points should be considered in light of other factors affecting wetland water levels. Ecological Land Services' (ELS) has documented significant water level changes in Wetland A that apparently result from human and beaver activity, as well as the natural influences of climate. A 60-year record of site conditions (1941 to 2002) is documented in a series of seven air photos interpreted by ELS. Man-made drainage features and a general lack of beaver dams are evident during the middle part of the 20th Century when a part of Wetland A was farmed. Those conditions are associated with an observed smaller wetland area and low water levels.

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7 Ecological Land Services, Inc., April 23, 2004, Response to MDNS Comments on Maytown Aggregates
By 1980, drainage features ceased to be maintained, and beaver activity became prominent. Overall, ELS interprets that water levels have risen 3 to 4 feet over much of Wetland A over 60 years, largely as a result of cessation of drainage and an increase in beaver activity.

**Prediction of Seasonal Effects on Water Levels Caused by Open-Water Evaporation**

Current predictions of *seasonal effects* of lake evaporation on groundwater and wetland water levels also differ significantly from prior predictions. Whereas prior predictions suggested induced seasonal water-level variations up to several tenths of a foot, corrected predictions suggest induced seasonal variations that are less than one tenth of a foot, which is clearly insignificant. It should be noted that *natural* seasonal variations in groundwater levels are documented to range from 4 to 11 feet on site. Natural variations will continue to occur after mine excavation. The modeling analysis estimates the seasonal change from those current conditions resulting from lake evaporation.

The model used to predict effects on the wetlands assumes that the wetlands are entirely dependent on groundwater to maintain water levels. We know that wetland and groundwater levels are indeed similar and that over much of the year Beaver Creek completely infiltrates upstream of Finger 4 – indicating that no surface water source can be contributing water at those times. However, during periods of high flow in Beaver Creek, the fingers of Wetland A may be recharged by surface water from the creek. The mine will not affect stormwater flows in Beaver Creek.

Summer water levels in the wetlands would be affected by flows from Beaver Creek to the extent that beaver dams and low permeability wetland soils prevent loss of the stored surface water back to the creek or to the aquifer in the spring and summer months. Although beaver dams are shown to affect water levels in the creek and wetlands (Ecological Land Services, 2004), we expect that long-term storage of winter stormwater flows does not occur.

**Prediction of Lake Effect on Average Annual Water Flow**

The preceding sections described how lake effects and increased evaporation would be reflected in water levels. This section describes how these effects would be reflected in flow rates in Beaver Creek, Allen Creek, and other points of groundwater discharge represented by the model (e.g. Deep Lake and subflow out of the model domain). The analyses are based on the same model runs and are internally consistent. That is, higher water levels are shown to cause increased water flow rates compared to current conditions, and declining water levels are shown to cause lower flow rates. Although the computer model has been constructed with care in regards to allocating flow rates to either Beaver or Allen Creeks, the creeks occupy a common portion of Wetland A and the wetland is continuous between the two streams. The model’s differentiation of flows may be more pronounced than would actually occur in the field. Also, as described in Appendix A to the Expanded Environmental

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8 The first analysis of seasonal evaporative effects was presented in *Response to Comments on Thurston County MDNS for Maytown Aggregates*, Pacific Groundwater Group, April 23, 2004. The findings on seasonal effects in that report are superseded because of the software flaws and subsequent model refinements.
Checklist, Allen Creek discharges back into Beaver Creek downstream. Therefore, on a basin-wide scale, differentiation of the effects between the two streams is moot.

On the basin-wide scale, a reduction of annual average flow in the Beaver Creek drainage (streams plus other discharge points) is likely as a result of open water evaporation from the lakes. The reduction is equal to the difference between current evapotranspiration from the prairie and trees versus future evaporation from the open water. Our estimate of this number has not changed since being reported in the Expanded Environmental Checklist. It was calculated to be 0.13 to 0.15 cubic feet per second (cfs) based on different estimates of water surface area. That is less than one percent of estimated total groundwater flow in the basin.

On a smaller scale, changes in flow were divided between: 1) Allen Creek and Deep Lake (to which Allen Creek is tributary), and 2) Upper Beaver Creek and its associated area of groundwater subflow out of the model domain. The corrected model was used to perform the calculations. Results indicate that the higher water levels in the Beaver Creek area would be associated with an average annual increase in Beaver Creek flow (including the associated groundwater discharge to subflow) on the order of 0.14 cfs. Likewise, the lower water levels in the Allen Creek area would be associated with an annual average reduction in discharge to the stream plus Deep Lake on the order of 0.28 cfs. The net change in flows is equal to the basin-wide change indicated in the paragraph above, 0.15 cfs (with rounding).

**EFFECTS ON WELLS**

As discussed in Appendix A of the Expanded Environmental Checklist of July 2002, effects of mining are unlikely to impair the functioning of properly constructed wells at any off-site location. This finding remains true considering the corrected model results discussed above. The following paragraphs provide additional discussion.

Figure 10 in Appendix A of the Expanded Environmental Checklist of July 2002 is a map of well density near the project. The number of wells in each quarter-quarter section of land (40 acres) is indicated based on analysis of Washington State Department of Ecology’s well log database. The figure also has symbols showing five locations where off-site supply wells are either confirmed or likely, and are not documented in Ecology’s well database.

The mining activities that could adversely affect wells are water level declines and well water becoming turbid as a result of migration of suspended clay through the aquifer. Permanent water level declines could occur as a result of the effects of the pit lakes, and temporary declines could occur as a result of extraction of gravel and pumping (consumption) of water for the industrial activities. All these effects were analyzed as part of the Expanded Environmental Checklist submitted in July 2002; however, as discussed above, predictions of lake effects have changed.

The combined water level effects are expected to be less than approximately 3 feet at any off-site location. Because of their closer proximity to pit lakes, wells east of the property (along Angus Drive SE) are more likely to be affected than wells in other areas – although under the
expected lake skin condition, wells east of the pits are likely to eventually experience a water level rise. Negative impacts to wells are generally caused by ambient groundwater level declines that are large relative to the available drawdown. Wells on the north, south, and west are at least 2000 feet from the nearest pit, and in most cases are separated from the pits by either Beaver or Allen Creek; thus those wells are too far away to experience noticeable effects.

Well logs from wells east of the property were reviewed to understand their construction and vulnerability to impacts. Whether or not wells are impaired by a change in water level depends on the water level change compared to the extent that the well penetrates below the water table when it is pumping. The well logs indicate that wells in that area range from 35 to over 100 feet deep, and that they penetrate from 15 feet to over 100 feet below the water table when not pumping ("static water levels"). Although pumping water levels are not reported on the well logs, the small yield of the wells and the high permeability of the local glacial aquifers suggest that pumping water levels are not too different than static water levels. Although no impairment to these wells is predicted, the enclosed groundwater monitoring plan includes provisions to document the location, construction, and performance of off-site wells, analyze off-site effects, and modify or replace wells materially impaired by mining operations.

ANALYSIS OF IMPACTS FROM THE GETCHELL GRAVEL MINE, PILCHUCK VALLEY, WASHINGTON, BY R.J. RONGEY

Pacific Groundwater Group reviewed Rongey Associates' recent analysis of hydrologic impacts of mining in the Pilchuck Valley. Three pits were mined below the water table over a period of more than 10 years. Like the Maytown site, the mined formation in Pilchuck is of glacial-outwash origin and comprises a high permeability surficial aquifer. Water level measurements and groundwater-flood occurrences were used to assess hydrologic impacts of mining. Major findings of that analysis include:

- **Groundwater storage increases as a result of excavation, and the extra storage buffers (smoothes-out) annual and seasonal water level fluctuations.** The extra water storage created by the lakes is included in our analysis at Maytown.

- **Seasonal and long-term changes in water levels in the pit lakes and aquifer are similar.**

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10 Although the Pilchuck monitoring program was apparently sufficient to identify hydrologic effects and protect environmental resources, we note that the hydrologic monitoring program proposed for the Maytown project is far more rigorous than the one implemented in Pilchuck.
• Contrary to conditions that would be predicted with a lake effect and no lake skin, down-stream groundwater-flooding has not increased.

• The regional groundwater gradient has not changed as a result of mining.

• The lakes do not affect groundwater recharge. Our analysis indicates that a small reduction in recharge will occur as a result of open-water evaporation.

• Collapse of pit side walls destroys alluvial structures (layering) and contributes to reduction in pit wall permeability. In Rongey’s analysis, the water-level difference in adjacent pits was observed to increase substantially following a side-wall collapse. The water-level-difference across a 250-foot inter-pit berm was about the same as the difference across 1300 feet of pre-mining aquifer.

Rongey Associates’ analysis of field data from the Pilchuck site suggests less hydrologic impact than predicted by our theoretical analysis of the Maytown project. The lack of significant adverse impacts apparently results from a combination of increased groundwater storage and natural processes that have prevented significant lake effects.

**DETAILED GROUNDWATER MONITORING PLAN**

The enclosed Groundwater Monitoring Plan (Appendix B) has been revised from earlier plans to address concerns raised in communication between the County and Allen & Company and to compliment the conservation agreement. The following documents have previously proposed or stipulated groundwater monitoring for Maytown Aggregates:

• Appendix F of Appendix A to the Expanded Environmental Checklist of July 2002 contained a groundwater monitoring plan for water levels and groundwater turbidity, including procedures and reporting requirements.

• Response to Comments on the Expanded Environmental Checklist in a letter from Pacific Groundwater Group to Thurston County of October 25, 2002 proposed monitoring to comply with the NPDES general permit.

• The MDNS Re-Issuance document written by the County dated May 4, 2004 stipulated that a monitoring well be established upgradient and downgradient of each pit.

• Response to MDNS comments briefly discussed the feasibility of identifying small mine-related water level changes.

• The June 8 2004 letter from Tony Kantas of Thurston County to J. Allen of Allen & Company.
The revised plan of Appendix B proposes locations, frequencies, parameters, methods, and actions pertaining to the following groundwater regulations and concerns:

- impairment of off-site supply wells
- changes in water levels and quality resulting from mining
- NPDES monitoring

This plan requires water monitoring at 17 stations within and surrounding the mine. Four stations are specific to NPDES monitoring of the process water. The other 13 stations serve the purposes of monitoring for protection of off-site wells and the wetland. Five stations are near (upgradient and downgradient) of proposed pit lakes. The remaining eight stations surround the pit lakes on the east, south, and west and lie between the pits and off-site water resources that require protection. These perimeter stations will provide the best data for assessing off-site impacts because they are closest to the off-site water resources. This plan will provide ample data to address the three monitoring objectives listed above, and will augment the conservation agreement reached between Allen & Company and the environmental organizations. Providing a monitoring well upgradient and downgradient of each pit lake, as stipulated by the County in the May 4, 2004, MDNS document, is not necessary or advisable to address the monitoring objectives and is not proposed herein.

**SUMMARY**

The new information presented in this letter report indicates that impacts from mining are likely to be less intense and/or easier to mitigate than impacts indicated by prior analyses. In review:

- The new analysis indicates that water level changes resulting from pit lake effects are small and will develop slowly over many years. The gradual nature of the water level changes should be considered by ecologic specialists in regard to the significance of the effects.
- The new analyses indicate that seasonal evaporative effects on water levels are insignificant.
- The predicted changes to water levels in Wetland A are smaller than changes caused by man and beavers in the 20th Century, and will develop over similar or longer time frames.
- The appended groundwater monitoring plan will provide a background and foreground data set for water levels and water quality that can be used to assess mining impact. It also provides criteria and response actions for repair or replacement of off-site water supply wells.

Our study and monitoring of this site since the mid-1990s has resulted in a very good understanding of the site hydrogeology. We have modified the model that represents that hydrogeology in response to agency and public comments, peer review, a natural desire for improvement, and the unfortunate software error. Our internal process and our work with the State and environmental organizations has provided us a broad understanding of
the factors important in predicting impacts. At this time we are confident that our simulations accurately reflect our estimates of future conditions, and that our estimates of future conditions are reasonable. Because of the remaining uncertainties, we also provide a monitoring plan as a basis for adaptive management of hydrologic effects. Should you have questions, we are always available to answer your questions, at 206-329-0141.

Respectfully,
Pacific Groundwater Group

Charles T. Ellingson
Principal

Attached:
Table 1 – Schedule for Mine Expansion Used in Modeling
Table 2 – Expected Water Level Change at Observation Points over 20 Years

Figure 1 – Feet of Expected Average Annual Water Level Change after 20 Years (expected, unmitigated skin)
Figure 2 – Expected 20-Year Trend in Water Level Change
Figure 3 – Feet of Average Annual Water Level Change after 20 Years (No Skin)

Appendix A – Letter from Environmental Simulations, Inc.
Appendix B – Groundwater Monitoring Plan, Revision 2
Table 1 – Schedule for Mine Expansion Used in Modeling

<table>
<thead>
<tr>
<th>Year</th>
<th>Mine Area</th>
<th>Million Cubic Yards Mined at end of time segment</th>
<th>Cumulative Cubic Yards Mined</th>
<th>Modeled Lakes</th>
<th>Steps</th>
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<td>0</td>
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<tr>
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<td>20.00</td>
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<td>8</td>
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Table 2 – Expected Water Level Change at Observation Points over 20 Years (expected, unmitigated lake skin)

<table>
<thead>
<tr>
<th>Run</th>
<th>Year</th>
<th>Lakes Added</th>
<th>Finger-4</th>
<th>Finger-3</th>
<th>Beaver-Finger-4</th>
<th>Finger-1</th>
<th>Lake-6</th>
<th>MT-9</th>
<th>MT-11</th>
<th>PP-01</th>
<th>PP-10</th>
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<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
</tr>
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<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<td>-0.1</td>
<td>0.0</td>
<td>1.0</td>
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<td>0.0</td>
<td>0.0</td>
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<td>1.9</td>
<td>1.6</td>
<td>-0.1</td>
<td>-0.1</td>
</tr>
</tbody>
</table>

All values are in feet
Negative values indicate a water level decline
Positive values indicate a water level rise

See Figure 1 for observation point locations.
Figure 1 – Feet of Expected Average Annual Water Level Change after 20 Years (expected, unmitigated skin)

Positive = Increase in water levels
Negative = Decrease in water levels
Figure 2 – Modeled 20-Year Trend in Water Level Change (expected, unmitigated lake skin)

See Figure 1 for observation point locations.
Figure 3 – Feet of Average Annual Water Level Change after 20 Years (No Skin)

Positive = Increase in water levels
Negative = Decrease in water levels
APPENDIX A

LETTER FROM ENVIRONMENTAL SIMULATIONS INC. REGARDING SOFTWARE ERROR
September 13, 2004

Charles Ellingson
Pacific Groundwater Group
2377 Eastlake Ave East
Seattle, WA 98177

Re: Correction of GW Vistas / MODFLOW2000 Interface

Dear Mr. Ellingson:

As discussed with your staff over the last week or so, your understanding of the problems between GW Vistas and the MODFLOW2000 HFB package prior to the June, 2004 update to GW Vistas is correct. I confirmed your interpretation by running your model with the pre-June and post-June Vistas software. I appreciate your need to communicate to your clients, peer reviewers, and regulatory agencies what happened, and I hope my explanation below helps. I would be willing to discuss this directly with any of them if that would be of assistance.

Here is what happened:

- In versions of Groundwater Vistas prior to June 16, 2004, the conductance (variable hydchr) written by Groundwater Vistas to the HFB Package for MODFLOW2000 was not correct for confined layers. This problem did not effect MODFLOW96, nor did it affect unconfined layers in MODFLOW2000.
- The problem was identified and fixed on June 16, 2004 and an update was immediately issued.
- Because of the vistas/modflow interface problem, the earlier modflow model runs were made with an hfb ("lake skin" in your case) permeability for confined layers that was not consistent with your input to vistas. The earlier runs understated the effect of the lake skins relative to the input you specified.
- As of June 2004 the problem has been corrected and your current simulations correctly reflect the effect of the hfb (lake skins).
This is a very unusual situation for Groundwater Vistas (and ModelCad before it). It is the first time in the 15 years I have been developing such software that I have identified an error in generating MODFLOW datasets. I believe that Groundwater Vistas continues to be the most reliable preprocessor for MODFLOW and MODFLOW2000 and we will continue to work towards making it better. Groundwater Vistas and MODFLOW are used extensively by the USGS, US EPA, state agencies and consultants around the world and we are here to support them.

Again, I apologize for the difficulty this has caused you, your client, and the project. My experience working with Pacific Groundwater Group gives me confidence that your use of GW Vistas and MODFLOW are reliable, and that your analyses with the new GW Vistas / MODFLOW interface will be correct.

Sincerely,

Environmental Simulations, Inc.

[Signature]

James O. Rumbaugh, III
President
APPENDIX B

GROUNDWATER MONITORING PLAN
Maytown Aggregates Groundwater Monitoring Plan

Revision 2

Purpose

The purpose of this groundwater monitoring plan is to generate information that will address the following issues and regulatory requirements:

- The potential for impairment of off-site water supply wells
- Changes in water levels and quality resulting from mining
- NPDES monitoring requirements

These requirements have been established through communication between Allen & Company and Thurston County, with the primary references being:

- Appendix F of Appendix A to the Expanded Environmental Checklist of July 2002 contained a detailed groundwater monitoring plan for water levels and groundwater turbidity, including procedures and reporting requirements.
- Response to Comments on the Expanded Environmental Checklist in a letter from Pacific Groundwater Group to Thurston County of October 25, 2002 proposed monitoring to comply with the NPDES general permit.
- The MDNS Re-Issuance document written by the County dated May 4, 2004, which stipulated that a monitoring well be established upgradient and downgradient of each pit.
- Pacific Groundwater Group’s response to MDNS comments briefly discussed the feasibility of identifying small mine-related water level changes.
- The June 8, 2004, letter from Tony Kantas of Thurston County to Jay Allen of Allen & Company, which requested a plan to remedy impaired off-site wells, if any.

Overview

This plan addresses the requirements above through monitoring of on-site water levels and water quality, including measurement of background conditions, and by documenting the construction and performance of off-site water supply wells prior to mining. The plan includes monitoring and action elements referenced in all of the documents listed above.

Water monitoring is required at 17 stations within and surrounding the mine. Four stations are specific to NPDES monitoring of the process water. The other 13 stations serve the purposes of monitoring for protection of off-site wells and the wetland. Five stations are near
(upgradient and downgradient) of proposed pit lakes. The remaining eight stations surround the pit lakes on the east, south, and west and lie between the pits and off-site water resources that require protection. These perimeter stations will provide the best data for assessing off-site impacts because they are closest to the off-site water resources. This plan will provide ample data to address the three monitoring objectives listed above, and will augment the conservation agreement reached between Allen & Company and the environmental organizations. Providing a monitoring well upgradient and downgradient of each pit lake, as stipulated by the County in the May 4, 2004, MDNS document, is not necessary or advisable to address the monitoring objectives and is not proposed herein.

The plan is divided into the following major sections:

- Remedy if Off-site Supply Wells are Impaired
- Groundwater Level and Temperature Monitoring
- Overview of Groundwater Quality Monitoring for the NPDES General Permit

The elements of this plan need to be considered along with monitoring that will be performed by State agencies and environmental organizations for full appreciation of the scope of environmental monitoring.

**Remedy if Off-Site Supply Wells are Impaired**

This portion of the plan stipulates that nearby off-site water supply wells be documented and that wells that are shown to be impaired by mining activities be fixed or replaced. To avoid repeated intrusion into private and public supply wells, groundwater level monitoring will occur in on-site wells that are representative of (and more affected than) off-site conditions.

Wells in the following areas will be field-verified within one year of receipt of the mining permit. The inventory will be updated every five years during mine operation.

T16N R2W:
- west half of section 6
- northwest quarter of section 7
- southwest quarter of section 2
- northeast quarter of section 10
- south one-half of section 11
- south one-half of section 12

Assuming that access is granted by land owners and that the well is configured so that measurements can be taken, the following data will be collected for each well. If allowed, a unique well identifier provided by the State Department of Ecology will be affixed to the well. The County will be provided a report that documents the well inventory.
Table B-1. Off-Site Well Inventory Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>Pumping rate</td>
</tr>
<tr>
<td>Location</td>
<td>Typical water use and well problems</td>
</tr>
<tr>
<td>Contact information</td>
<td>Water treatment facilities</td>
</tr>
<tr>
<td>Well log</td>
<td>Specific conductance</td>
</tr>
<tr>
<td>Diameter</td>
<td>pH</td>
</tr>
<tr>
<td>Total depth</td>
<td>turbidity</td>
</tr>
<tr>
<td>Depth of openings</td>
<td>odor</td>
</tr>
<tr>
<td>Pump set depth</td>
<td>iron-related bacteria activity measurement</td>
</tr>
<tr>
<td>Depth to static water level</td>
<td>appearance of wellhouse, well, and water</td>
</tr>
<tr>
<td>Depth to pumping water level</td>
<td>photo of well house and well head</td>
</tr>
</tbody>
</table>

To avoid repeated access to these private and possibly public water supply sources, routine (ongoing) water level measurements will not be collected from these wells. Instead, monitoring wells will be established to measure mining effects between the off-site supply wells and the mine. The following wells will be used for this purpose:

Table B-2. On-Site Monitoring Locations to Assess Off-Site Water Level Changes

<table>
<thead>
<tr>
<th>Location</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast and East of the site:</td>
<td>MT-9, MT-11</td>
</tr>
<tr>
<td>South of the site:</td>
<td>A new monitoring well drilled as far south as possible between Wetland A fingers 3 and 4</td>
</tr>
<tr>
<td>West of the site:</td>
<td>PP-10</td>
</tr>
</tbody>
</table>

The monitoring wells will be surveyed and manual water levels and water temperatures will be measured six times yearly starting not later than the issuance of the mining permit, and will continue for the duration of mining. Alternatively, the operator may choose to install data loggers in the wells. In that case, manual measurements may be reduced to four times per year, with the loggers programmed to collect daily water levels. In addition to routine reporting discussed below, data will be made available to County staff upon reasonable request.

Well owners with problems that they believe are caused by the mine must first contact the County and provide evidence of the impairment. Based on the evidence presented, a licensed County hydrogeologist or engineer may choose to visit the site and perform an inspection. Although the County inspection would not be required, such an inspection is required before the County may request action by the mine operator, and the County must present evidence to the mine operator of probable cause that the impairment is caused by the mine. With regard to problems related to pumping rates or volumes, probable cause must include a preliminary analysis indicating that the static water level in the well has declined more than would be caused by natural variability plus changes in local water use. With regard to
changes in water turbidity, probable cause must include evidence of increased turbidity that is not explained by local conditions, including bio-fouling of the well and pump problems. The mine operator will provide the County with any requested monitoring data during this evaluation.

Upon request by the County, and after the County's preliminary evaluation referenced above, the mine operator will contact the well owner and quickly perform an independent evaluation of the reported well problem. If the County's inspection results in a finding of probable cause as defined above, and the results of the mine operator's independent evaluation concurs with the County's finding, the mine operator shall either repair the identified impairment or replace the well. The standard of acceptance for a repaired or replaced well will be one that yields a similar amount of water as the original, and that has comparable water quality. At anytime during this process, the mine operator may choose to repair or replace the well without further evaluation.

In the event that the results of the independent evaluation do not concur with the County's finding, the County and the mine operator shall engage a third party, either a licensed hydrogeologist or engineer, to evaluate the claimed impairment and shall be bound by the results of his or her findings. The mine operator shall pay for the third party's analysis. The third party shall be chosen as follows: the mine operator shall identify three licensed hydrogeologists or engineers and County shall choose one of these licensed hydrogeologists or engineers to perform the evaluation. If the conclusion is a finding of probable cause as defined above, the mine operator shall either repair the identified problem or replace the well to the standard specified above.

Groundwater Level and Temperature Monitoring

Monitoring Stations

Stations listed in Table B-3 will continue to be used to monitor groundwater and wetland water levels and temperatures.

<table>
<thead>
<tr>
<th>Wells</th>
<th>Surface Water Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT-5</td>
<td>DL1</td>
</tr>
<tr>
<td>MT-6</td>
<td>BC1</td>
</tr>
<tr>
<td>MT-8</td>
<td>BC2</td>
</tr>
<tr>
<td>MT-9</td>
<td>wetA1</td>
</tr>
<tr>
<td>MT-10</td>
<td></td>
</tr>
<tr>
<td>MT-11</td>
<td></td>
</tr>
<tr>
<td>PP08</td>
<td></td>
</tr>
<tr>
<td>PP10</td>
<td></td>
</tr>
</tbody>
</table>

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Some of the wells are located within future pits and will be destroyed in the process of mining. Wells MT-8 and MT-10 would likely be destroyed within the first 5 years of mining, whereas wells MT-6 and MT-5 would not be destroyed until 10 to 15 years after mining starts. The perimeter wells will not be destroyed by mining.

One additional monitoring station will be established between Wetland A fingers 3 and 4 prior to any pit being excavated below the water table (Table B-4).

**Table B-4. Monitoring Stations to be Added**

<table>
<thead>
<tr>
<th>Wells</th>
<th>Surface Water Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>One well as far south as possible between fingers 3 and 4</td>
<td>None</td>
</tr>
</tbody>
</table>

The new well will be constructed of 2-inch diameter PVC and be screened slightly below the water table. All wells will be physically secured to prevent entry or vandalism. Measuring points will be clearly marked and surveyed to NGVD29 datum. Unused wells will be decommissioned in accordance with Chapter 173-160 WAC regulations.

**Monitoring Personnel**

Professional or on-site personnel will perform the water level monitoring. If on-site personnel are used, a licensed professional hydrogeologist will train the on-site personnel during an initial round of monitoring, assist in setting up the data management system, and must stamp any report consistent with State licensing requirements.

**Water Level and Temperature Monitoring Parameters**

The time, date, measuring point, depth-to-water, and water temperature will be recorded at each monitoring well, along with the name of the person making the measurement. Also, related mine-activity data will be recorded to assist in the reporting discussed below.

Measuring depth-to-water in the wells will require the use of an electric water level sounder. Stage height at the gaging stations will require a hand tape. At station wetA1, the height of water above the measuring point is read directly from the stage gage.

Temperature measurements will be made with a hand-held, remote-reading, down-hole thermometer. The thermometer will be lowered into the bottom portion of the well screen and the temperature of the groundwater will be read off of the hand-held meter. The wells will not be purged.
Water Level and Temperature Monitoring Schedule

Background and foreground water monitoring will occur. Background water level data are considered to be those measurements collected before mining penetrates the water table south of the train tracks. Foreground monitoring begins immediately after background monitoring. The same parameters and frequency of data collection will occur in the background and foreground periods.

Monitoring will begin under this program no later than receipt of the mining permit and continue until one month after reclamation is complete. Monitoring will continue during periods of gravel-mine inactivity, unless approved otherwise by the County.

If data loggers are not used, manual water levels and temperatures will be measured every other month at each station. If data loggers are used, they shall be programmed for daily water level and temperature measurements, and manual measurements may be decreased to quarterly. Data logger data shall be downloaded and secured quarterly.

Data Management

One copy of data collection forms will be kept on file at the site or the operator's corporate office and another copy will be provided to the County. The County shall maintain a secure file of project data. In addition, the owner will enter the data into a computer database which will record the date, time, person, depth-to-water, and water temperature at each station. A copy of the database will be provided to the County annually.

Data Analysis and Reporting

The owner will summarize the mining and water monitoring activity in a report to the County every two years. The hydrologic report will include:

- A map showing the extent of aggregate extraction (below the water table) at the beginning and end of the two-year period.
- The depth of each pit below the water table, if applicable.
- A summary of water use during the two-year period.
- Plots of water levels and temperature over time for the entire period of record.
- Comments on mine activities or the monitoring program pertinent to interpretation of the data.

A licensed hydrogeologist will generate the report or review the report and comment on the program at this two-year interval.
The owner will analyze the water monitoring data every second reporting period (every four years). The analysis will be summarized in an expanded report to the County and include the data and comments listed above plus:

- An analysis of water level and temperature changes or trends considering potential mining effects, background (regional) changes, water level changes permitted under existing water rights, beaver activity, and other factors the owner recognizes as pertinent.
- Identification of significant adverse water level or temperature changes likely caused by mining (the lakes or gravel extraction).

The report will be generated or reviewed and approved by a licensed hydrogeologist.

**Overview of Water Quality Monitoring for the NPDES General Permit**

Training of samplers, water sampling at selected stations, and reporting will meet requirements of the NPDES Sand and Gravel General Permit. There will be no discharges to surface water, therefore sampling requirements are those for discharging stormwater and process (wash) water to the ground. The wash water will be discharged to sand-lined sedimentation ponds and largely reused. Analysis requirements are monthly testing of water in sedimentation ponds for pH, and daily visual examination for oil sheen.

In addition, the project will conduct groundwater monitoring at least quarterly, nearby and down-gradient of the sedimentation pond, regardless of whether the volume of discharge to groundwater exceeds 15,000 gallons per day (which is the regulatory threshold). Background samples will be collected from monitoring stations prior to mining. Groundwater analysis parameters will include temperature, specific conductance, turbidity, and possibly dissolved iron and manganese.

Surface water and groundwater monitoring stations are proposed to comply with General Permit requirements. Surface water stations will be the sedimentation pond or ponds, as well as other locations where stormwater collects. The following wells will be used to monitor groundwater quality downgradient of the sedimentation ponds:

- PP02 (a shallow downgradient water supply well)
- PP04 (a shallow downgradient/cross-gradient water supply well)
- One new monitoring well

PP02 is the supply well for the on-site residence and office. PP04 is one of the supply wells for the onsite industrial facilities. In both cases, samples will be collected from the spigot closest to the well (if possible, upstream of any storage or pressure tank that may be present).

The new monitoring well will be located near the downgradient (west) side of the sedimentation pond. Special attention to well development and sampling procedures will be
implemented to reduce initial drilling-induced turbidity, and to produce consistent turbidity data over time.

All wells will be physically secured to prevent entry or vandalism. Measuring points will be clearly marked and surveyed to NGVD29 datum.

On-site or professional personnel will perform the monitoring. If on-site staff are used, a professional hydrogeologist will train the on-site personnel during an initial round of monitoring, and assist in setting up the data management system, as requested.

The operator will report NPDES monitoring data quarterly in accordance with General Permit requirements, using the standard forms available from Ecology.

In addition, the data collected from NPDES monitoring stations will be incorporated into groundwater monitoring reports submitted to the County as described earlier for other groundwater monitoring.
September 27, 2005

Jessica M. Jensen
Jessica McKeegan Jensen
6245 Guerin Street SW
Olympia, WA  98512-22443

Subject: Hydrogeologic Modeling and Predicted Impacts, Maytown Aggregates

Dear Ms. Jensen,

The purpose of this letter is to provide documentation that I met earlier this year with Pacific Groundwater Group to learn about their revised groundwater model and their revised predictions of impacts associated with the proposed Maytown Aggregates mining operation. As described more fully below, the revisions that have been made to the model address my concerns and I concur with PGG's assessment that mining operations will cause groundwater level changes that will likely fall somewhere between 2 feet of decline (if there is no "skin" effect) to 1 foot of increase (if there is a significant "skin" effect).

In my letter to Sue Danver dated May 18, 2004, I expressed several concerns regarding the proposed gravel mining operations at the Maytown Aggregates site in Thurston County. Those concerns revolved around questions about the approach used to predict the effects of lakes that will result from the mining operation. In particular, I identified questions regarding the methodology used to quantify the effects of the lakes in terms of lowering water levels in the wetlands and reducing discharge in the streams. I also expressed concerns about the technical and economic feasibility of a proposal to construct a 4-foot thick, low-permeability liner to mitigate the effects of the lakes, if mitigation were to be required.

At Ms. Danver's request, I met with Charles "Pony" Ellingson and Dawn Chapel at Pacific Groundwater Group's (PGG) offices in Seattle to discuss the Maytown Aggregates project on March 23, 2005. Mr. Ellingson is a Principal Hydrogeologist with PGG and Ms. Chapel has been involved in recent modeling work for the Maytown site. During our meeting, Mr. Ellingson and Ms. Chapel described their understanding of the geology and hydrogeology in the vicinity of the Maytown site. They described additional water level data that have been collected during the last twelve months from groundwater wells and from a gauge in the wetland designated as "A1" (Finger 4...
of Wetland A). These additional data show the relationship between water levels in the wetland and in groundwater wells over an annual cycle. These data were not available last May.

Mr. Ellingson and Ms. Chapel also presented the results from additional simulations using the computer model that has been developed to describe the groundwater system. The materials that were presented during our meeting address the issues that were raised in my earlier letter, as described below.

**Additional simulations to address how lakes are incorporated in the computer model**

Additional simulations have recently been completed that directly address the issue that I had raised in my May 18, 2004 letter concerning the methodology used to incorporate the lakes into PGC's computer model. As you may recall, the model used to simulate the effects of the Maytown Aggregate lakes does not treat these features as true lakes. Rather, these lakes are treated as higher-permeability zones within the existing geologic materials. While these high permeability zones will cause preferential flow paths similar to true lakes, it was not clear, based on the results that were available in May of 2004, whether this approximation provides conservative estimates of impacts. I suggested that it would be useful to do additional simulations to evaluate the sensitivity of the computer predictions to the permeability or hydraulic conductivity assigned to the lake features. For the approach to be valid, the results should not depend upon the hydraulic conductivity assigned to these high-permeability zones.

The results that were available in May of 2004 were developed by assigning a hydraulic conductivity to the lakes equal to 20,000 feet per day (ft/day). Two additional sets of simulations have been completed since May 2004. In the first set of simulations, the hydraulic conductivity of the lakes was increased by a factor of ten to 200,000 ft/day. According to PGC, the results from the revised model were different from the original results (i.e., the 20,000 ft/day results). In the second set of simulations, the hydraulic conductivity of the lakes was increased to 2,000,000 ft/day. The results from these simulations were the same as from the simulation using 200,000 ft/day. This suggests that the 200,000 ft/day value is sufficiently high to reasonably simulate the lakes. These results satisfy my concerns regarding the methodology used to simulate the lakes.

**Effects liners or "skins" on groundwater levels**

The results from the original computer simulations that were available in May of 2004 indicated that a 4-foot thick liner of silt or clay material with a hydraulic conductivity value of 0.03 feet per day would be required to mitigate the potential effects of lakes on the groundwater levels and stream flow. I expressed concern in my May 18, 2004 letter regarding the technical difficulties and economic costs that might arise in constructing this type of liner.
The required characteristics of the liner or "skin" that would be needed to mitigate effects of the lakes were identified using the groundwater model for the Maytown site. This model was developed by PGC using a software package that is entitled GW Vista. This software is an industry standard that has been widely used by hydrogeologists and engineers throughout North America and Europe. Because of a programming error or "bug" in this software package that had not previously been reported, the required thickness for the liner was significantly over-estimated.\(^1\) In our meeting on March 23, PGC described the results of simulations that they have developed using the corrected software. These simulations suggest that a much thinner liner would be needed to prevent the groundwater level declines that may result from the lakes that will remain after the site has been mined. Instead of a 4-foot thick liner with a hydraulic conductivity of 0.03 ft/day, the corrected model suggests that a liner that is 0.7 feet thick with a hydraulic conductivity 0.2 ft/day will reverse the groundwater water level declines and may actually result in water level increases in the wetlands.

I cannot say with confidence whether this type of skin can develop naturally or through mining operations and whether these skins will have the effect that is suggested by the computer model. While I have not seen any peer-reviewed or well-documented reports or studies that describe or confirm these effects, the effects are logical. It is also clear that a 0.7 foot thick liner or skin with a hydraulic conductivity of 0.2 ft/day is much more feasible and economically viable than a 4-foot thick liner with a hydraulic conductivity of 0.03 ft/day, as originally proposed.

**The range of feasible impacts on groundwater levels**

The revised and corrected computer model described above has been used to estimate water level declines and impacts to stream flow that may result from the mining operations. A range of potential effects may result, depending in large part upon the characteristics of the low-permeability "skin" referenced above. For example, if there is no skin, the revised model suggests that water levels in Finger 4 of the wetland may decline by as much as 2 feet. The model suggests that water levels at that location may increase by as much as 1 foot if there is a skin that is 0.7 feet thick with a hydraulic conductivity 0.2 ft/day.

It is not likely that additional modeling activities or additional background data will allow resolution beyond what is currently available in terms of the potential impacts of the lakes. Those impacts will likely fall somewhere between 2 feet of decline (if there is no "skin" effect) to 1 foot of increase (if there is a significant "skin" effect).

It is my understanding, based on discussions with PGC, that groundwater monitoring wells will be constructed on the upgradient and downgradient edges of

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\(^1\) I confirmed with James Rumbaugh, the developer of the GW Vista software, that this error was the cause of the over-estimation described above and that this error had not been previously identified prior to PGC bringing it to his attention. The error resulted from a very specific and unique set of features used in the Maytown model. In my estimation, PGC could not have reasonably foreseen this error or known of its existence or its effect on the simulation results.
some of the proposed lakes. These wells will be constructed prior to excavation and
will be monitored for water level changes. If there is no skin effect, water levels on the
upgradient end will likely drop and water levels on the downgradient end will likely
increase. These monitoring wells may allow some warning in terms of the impacts of
the lakes on groundwater levels.

Earlier today I received a copy of a letter report prepared by Pacific
Groundwater Group, dated September 26, 2005, and entitled "REVISED AND
EXPANDED ANALYSIS OF HYDROLOGIC EFFECTS FROM MINING, AND
PRESENTATION OF A REVISED GROUNDWATER MONITORING PLAN." I have not
reviewed that report. My opinions and comments provided above are based on the
information that was provided to me during the meeting that I had with PGG on

Sincerely,

Joel Massmann, Ph.D., P.E.
MAYTOWN AGGREGATES
SURFACE WATER MANAGEMENT

Prepared For

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Prepared By

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North Bend, WA 98045

Project No. 2002-12
September 2005
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<td>Maytown Aggregates, Vicinity Map</td>
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<td>B2</td>
<td>Maytown Aggregates, Existing Conditions</td>
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<td>B4</td>
<td>Maytown Aggregates, Infiltration Ponds</td>
</tr>
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</table>
2.2 EXISTING CONDITIONS

Most of the mine site is relatively flat with elevations ranging from 232 to 200 feet above mean sea level (Figure B2). The project area lies in a low, flat arc-shaped valley that extends from northeast to northwest and is interpreted as an ancient stream channel that was probably active during melting of glaciers. We refer to this feature as the "outwash channel". These soils are mapped by the SCS as Spanaway-Nisqually complex and are considered hydrologic group "A" (Thurston County Stormwater Manual, Table 5-2). A low upland with a steep south face runs along most the northern edge of the site, and marks a topographic change to undulating hills and valleys of glacial origin. The highest on-site elevation on this hill is about 350 feet above sea level.

The project area lies to the north of the Beaver Creek drainage basin and along the eastern side of the Allen Creek basin. Beaver Creek flows from east to west, south of the proposed project. The headwaters of Allen Creek lie to the west of the proposed project. A number of groundwater-fed wetlands are associated with both Allen and Beaver Creeks. Soils underlying the project area consist of gravelly sandy loam with a rather high infiltration capacity. Surface water features are absent within the mining area as a result of the highly permeable soils. Thus, there is no surface water connection between the project area and the off-site wetlands.

A number of exploration borings across the site encountered groundwater at an elevation between 215 and 210 feet or between 10 and 22 feet below the existing ground surface (Appendices A and C attached to the SEPA checklist). The ground water elevations are at about the same elevations as the wetlands. This fact and the lack of surface water connection from the mining area to the wetlands are consistent with wetland recharge being from ground water sources.

2.3 DEVELOPED CONDITIONS

The completed mining plan is shown on Figure B3 which indicates that there will be eight pond areas remaining in the sand and gravel mine areas, and two fill bodies composed of clean fill soil. The site will be developed in phases. As noted above, the proposed gravel extraction areas have high infiltration capacity, as evidenced by the lack of surface water features. The excavation areas will be developed such that all precipitation within a given mine area will be infiltrated. Run-off from the higher ground from the north and east will be either routed around a given excavation area or allowed to enter the excavation in a controlled manner and infiltrated.

Run-off in the clean fill areas will be controlled by means of a perimeter infiltration swale/conveyance ditches that will direct excess runoff to through sedimentation ponds that flow into an infiltration pond. Where possible, run-off from reclaimed areas will be directed away from the disturbed areas, so that it does not constitute a portion of the flow to be considered in the design of the infiltration / sedimentation pond system.

Non-extractive developed areas (roads, pads, aggregate stockpile areas) will be provided with ditches and best management practices (BMP) erosion and sediment control facilities.
• Soil stockpile slopes will be no steeper than 3 horizontal to 1 vertical, and will be re-vegetated as soon as practicable. Temporary cover measures such as mulching, nets and blankets will be installed where required.

• Drainage ditches will be armored and/or check dams installed where required.

4.2 SEDIMENTATION CONTROL

The following BMPs will be implemented to minimize the transport of suspended sediments off-site:

• Silt fences and/or natural brush filter barriers will be used around soil stockpiles until vegetation becomes re-established.

• Runoff requiring treatment will pass through ponds designed to promote sedimentation of suspended particulates. Design will be in accordance with the Washington Department of Ecology Stormwater Manual for Western Washington Section BMP C241, Temporary Sediment Pond. The design flow will be based upon the 10y24h event. The surface area of the pond at the top of the riser will be 2080 square feet per cfs of inflow.

• Vegetative filter strips and/or natural brush filters will be used as needed around the developed areas.