AR 015511

ACC's Prefiled Testimony, Supplemental Binder #1 of 1:
Testimony of Dr. Patrick Lucia
ACC & CASE v. DOE & POS, PCHB No. 01-160 02/22/02

BINDER 6

Pre-Filed Testimony of Dr. Patrick Lucia

Submitted on behalf of Appellant
Airport Communities Coalition

PCHB No. 01-160
ACC & CASE v. Dept. of Ecology & Port of Seattle

February 27, 2002

Supplemental Binder #1 of 1

ORIGINAL

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Pre-Filed Testimony of

Patrick C. Lucia, Ph.D.

Submitted on behalf of Appellant
Airport Communities Coalition

PCHB No. 01-160
ACC & CASE v. Dept. of Ecology & Port of Seattle

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ORIGINAL

1. This document constitutes my pre-filed testimony in the matter of Airport Communities Coalition (ACC) versus the State of Washington, Department of Ecology and the Port of Seattle regarding "Appeal of Section 401 Certification No. 1996-4-02325 and CZMA concurrency statement issued August 10, 2001, (amended September 21, 2001) related to Construction of a Third Runway and related projects at Seattle Tacoma Airport". This testimony is given in support of the ACC appeal of the 401 Certification. The exhibits to this document include various technical documents in support of this testimony.

QUALIFICATIONS

2. I am a Civil and Environmental Engineer having received my Ph.D. in Civil Engineering. I have over 25 years experience in both consulting and in academia. During the period of 1984 to 1986 I was a Visiting Lecturer in the Civil Engineering Department at the University of California at Berkeley, during 1990 to 1991 I was a Senior Lecturer at the University of California at Davis in the Civil Engineering Department. In 1989 I was an invited lecturer in a USEPA environmental technology transfer program in Korea and in 1995 was an invited lecturer at a NATO Advanced Study Institute on Groundwater pollution Control and Remediation in Turkey. I have also been a lecturer for the National Groundwater Association and the University of Wisconsin. My practice has broadly covered environmental and civil issues related to soils, groundwater and surface water. A copy of my CV is attached as exhibit A.

INTRODUCTION

3. My testimony will cover two major areas of the work by the Port relative to the Third Runway construction:

- Embankment fill screening criteria; and

- Low flow analyses.

4. In relation to the embankment fill screening criteria, the September 21, 2001 certification represents a relaxation of the requirements originally put forth in the August 10, 2001 Department of Ecology (Ecology) certification. In the August requirements, the Port was required to completely enclose fill with higher concentrations of metals and petroleum products within a six-foot layer of fill, completely covering the gravel drainage layer. This represents more stringent screening requirements than in the September 21, 2001 certification. . The proposed alternative in the September requirements would only apply the more stringent fill screening criteria restrictions to a wedge of fill above the drainage layer that measures 40 feet thick at the base of the embankment and tapers downwards at a 2% slope into the fill. The alternative proposed in September would allow the upper two thirds of the gravel drainage layer to have soil with higher levels of metals and petroleum contaminated soil allowed in the general fill criteria to be placed directly above the drain as shown on Figure 1. There does not appear to be any rationale given for this relaxation, nor any analysis demonstrating that the wedge of less-contaminated fill meets an equivalent or more protective standard than the six-foot enclosure required in the August certification. The major concern with the relaxed standards is that contaminated fill can be placed in the vicinity of or adjacent to the gravel drain that would act as a conduit for contaminants to the Creeks. In addition, criteria for allowable levels of metals are not consistent with the background levels in the Puget Sound area and the fill source characterization testing protocol is insufficient to assure the soils imported to the Third Runway will meet the environmental fill criteria.

5. In relation to the Port's low flow analysis, its purpose is to evaluate the impact that construction of the Third Runway Embankment will have on the rate at which runoff and infiltration recharges the creeks. The impact of the embankment is that it stores infiltrating water and subsequently releases it to recharge the low stream flows at different times than if the embankment were not in place. To mitigate the impact of the embankment, excess water must be stored and released to the creeks to maintain conditions that existed prior to the construction of the embankment. The analysis must be able to predict the magnitude of the impact of the embankment and provide a sound basis for calculating the required storage to maintain flows in the creeks. Like any work of this type, the results of the analyses must consider the reliability of the analytical method and the uncertainty of the parameters input into the analyses. If the analyses are not conservative then other sources of water must be available to make up any shortcomings in the water supply.

6. In the pre-filed testimony that follows, several key points and concerns will be made regarding the Low Streamflow analyses presented by the Port. The discussions are based largely on review of the November 27, 2001 report by Pacific Groundwater Group (PGG) titled "Port of Seattle - Sea-Tac Third Runway - Embankment Fill Modeling in Support of Low Streamflow Analysis." The discussions focus on the following essential findings:

- The Port's analysis fails to consider the substantial additional water requirements during the initial years of operation;

- The Port's analysis on the long term operation of the facility is not reliable and may significantly over estimate the rate at which water will flow through the embankment;
- The Port's analysis includes assumptions which have not been validated as to their reliability and impact on the results; and
- The Port's analytical approach of using a one dimensional version of Hydrus and then converting to the SLICE spreadsheet program appears to be an unnecessary complication that could be introducing additional errors into the analyses.

7. The Port's consultants have not demonstrated that this project as designed will satisfy the low streamflow requirements of the surrounding creeks. GeoSyntec's review of the Port's analyses, along with results of our own independent analyses, clearly show that following the completion of construction, the amount of water passing through the embankment into the underdrain is likely to be highly erratic and of a substantially lower quantity than the current low flow analysis predicts. The volume requirements of the storage vaults may be substantially under-designed. The under-design is due to the failure to calibrate the computer models being used; failure to evaluate the variability of the embankment soils; and an overestimation of the overall hydraulic conductivity of the soils in the embankment by ignoring the basic flow processes that will be occurring. Based on the Port's current low flow analysis it is impossible to predict whether the current vault sizes will be adequate on a long term basis. During the initial years of operation it is probable that insufficient water will be available from the vaults to mitigate the impacts to low stream flows.

EMBANKMENT FILL SCREENING CRITERIA

8. The apparent intent of the embankment fill screening criteria is to prevent the placement of contaminated soils within the embankment that could ultimately result in violations of Washington State water quality standards. The September 401 Certification permits placement of fill contaminated with metals above background levels for the Puget Sound area, and petroleum contaminated soils, in such a way that there is increased risk that state water quality standards will not be met. The September 401 Certification allows for soil contaminated with total petroleum hydrocarbons and metals above natural background levels to be placed next to the gravel drainage layer underlying the embankment. Placement of the contaminated fill next to the gravel drainage layer provides a short path by which these contaminants can be transported to the creeks. Fill criteria presented in the August 10,2001 certification were designed to mitigate the risk of contaminant transport from the embankment to the drainage layer. The alternative fill criteria allowed in the September 21, 2001, 401 Certification are less protective than the earlier criteria presented in the August 10,2001, Certification, as shown in Figure 1. Additionally, the September 21, 2001 criteria are less protective than and do not meet the requirements of the US Fish and Wildlife Service (FWS) Biological Opinion.

9. The proposed fill will be constructed over a drainage layer designed to carry water that infiltrates through the fill to the base of the embankment and wall. The fill may contain hazardous substances such as chromium, lead, nickel and diesel and other metals. A risk exists that water infiltrating through the fill could transport these hazardous substances through the drainage layer and into sensitive wetland areas below the embankment. The 401 Certification allows the Port to place fill containing TPH

contaminants and metals above natural background immediately above and adjacent to the drainage layer. As such, the Department of Ecology cannot have reasonable assurance that TPH and metals above natural background levels will not be introduced into groundwater, the wetlands and the streams below the embankment. In order to mitigate this risk, the proposed fill criteria in the 401 Certification dated August 10, 2001 provided requirements on the concentrations of chromium, lead, nickel and diesel that could be placed within the first six feet of the fill adjacent to the drainage layer, and within the six feet below the ground surface.

10. In her declaration Ms. C. Linn Gould states:

> "In addition to the protective soil fill criteria that were developed for the majority of the embankment, the U.S. Fish & Wildlife Service ("FWS") required the Port to construct a 40-foot wedge of fill along the western edge of the embankment that tapers along the natural contours of the underlying soil as it continues to the east, called the "drainage layer cover." ... The protective cover was designed to provide an "ultra-clean" layer of fill which will attenuate any potential contamination that might be leaching through the rest of the embankment above it, thereby giving FWS additional assurance that fill used in the Third Runway embankment would not adversely affect species listed under the Federal Endangered Species Act that may be present in nearby waters."

This proposed "wedge" alternative is included on page 18 of the September 21, 2001 Department of Ecology revised 401 Certification and is presented as an alternative to the previous soil fill criteria, rather than an addition. The proposed alternative would only apply the more stringent restrictions on the level of hazardous substances in a wedge of fill above the drainage layer that measures 40 feet thick at the base of the embankment and tapers downwards at a 2% slope into the fill. This means that fill above the drainage layer over the upper two thirds of the embankment will contain higher concentrations of hazardous substances than under the original screening criteria as shown in Figure 1. Higher concentrations of metals and petroleum products can be placed adjacent to the drainage layer and will not have an "ultra-clean" layer of fill to "attenuate any potential contamination that might be leaching through the rest of the embankment" as described by Ms. Gould. In addition, the changes from the August certification in the September certification will allow placement of higher concentrations near the ground surface, creating an increased impact on surface water runoff. The alternative clearly represents a reduction of the environmental standards for the project.

11. Under the August 10, 2001 certification requirements, Ecology required the Port to completely enclose the higher concentration fill within a six foot layer of fill with more stringent screening requirements, although to my knowledge there has been no analysis demonstrating the effectiveness of this method under these conditions. By itself, the alternative proposed in the September 21, 2001 certification represents a relaxation of the requirements, where the upper two thirds of the drainage layer are now exposed to soils with higher levels of metals and petroleum products. There does not appear to be any rationale given for this relaxation, nor any analysis demonstrating that a wedge of less contaminated fill placed immediately above the drainage layer in the configuration shown in Figure 1 meets an equivalent or more protective standard than the six-foot enclosure.

12. The drainage layer represents a significant pathway for transport of hazardous substances. If fill material with hazardous substances are to be placed in the embankment, the criteria for material placement adjacent to the drainage layer should not be relaxed.

13. The requirements of the Fish and Wildlife Service (FWS) Biological Opinion are not being fully adhered to in the September 21, 2001 401 Certification. This discrepancy creates the potential for application of a lesser standard than required. In their Biological Opinion, FWS states: "The surficial three feet of fill will be screened to not exceed the Proposed Ecological Standard or MTCA Method A, which ever is less." This requirement for more stringent control over the surficial three feet is not clearly incorporated within the text of the September 21, 2001 401 Certification, and may in fact be exceeded for chromium, lead, and selenium.

14. Unless the Port opts for the alternative that involves Attachment E to the Certification, (and there is no requirement that it do so) the drainage cover layer can consist of materials that are more "contaminated" than the naturally occurring area soils. In her declaration Ms. C. Linn Gould states "FWS required that metals in fill used in the drainage layer cover comply with numeric fill criteria equal to background concentrations (when available in the literature) found in the Puget Sound region. ... Therefore, the soil metals used in the drainage layer cover should consist of soil that is no more "contaminated" than naturally occurring area soil." However, when compared to Puget Sound background concentrations contained in the FWS Biological Opinion, the concentration of Arsenic, Cadmium, Lead and Mercury all exceed Puget Sound background levels. In addition, Exhibit C of the Gould Declaration shows that Chromium and Nickel also exceed Puget Sound background levels. In the case of Arsenic and Mercury, the levels allowed in the 401 Certification are approximately three times background levels in the Puget Sound area. As illustrated in the table on the following

page, of the nine listed contaminants for which natural background levels have been established, the six metals discussed above exceed natural background, in some cases significantly, and none of the contaminants are set at the Practical Quantitation Limits ("PQL") identified in DOE Technical Memorandum #3 PQLS as Cleanup Standards (November 23, 1993) ("Memorandum 3") (copy attached as Exhibit B).

Contaminant[1]	**401 Cert.**	**Puget Sound Background**[2]	**PQLS**[3]
Antimony	16		1.5
Arsenic	20	7	.5
Beryllium	.6	.6	.1
Cadmium	2	1	.05
Chromium	42/2000	48	.5
Copper	36	36	.5
Lead	220/250	24	.5
Mercury	2	.07	.002
Nickel	100/110	48	7.5
Selenium	5		.75
Silver	5		.1
Zinc	85	85	.03

The result is that the fill will in fact be more "contaminated" than naturally occurring area soil.

[1] All values listed in milligrams per kilogram ("mg/kg").
[2] As established by DOE publication 94-115 (October 1994).
[3] These values represent the minimum PQLS in mg/kg as stated in Table II of DOE Memorandum #3 (November 23, 1993).

15. A similar copy of this table was included in my declaration in support of the Stay. This version of the table contains information about Antimony which was omitted from my earlier declaration, and contains corrections regarding the lowest PQLs in Ecology Memorandum #3 for arsenic, cadmium, beryllium and chromium which were misstated in my declaration on the stay when these values were inadvertently shifted because of clerical error to the cell below. Thus, in my earlier declaration I mistakenly reported the following PQLs: arsenic (1.5), beryllium (.5), cadmium (.1), and chromium (.05). The correct minimum PQLS in Ecology Memorandum # 3 are in fact lower than previously stated for arsenic, beryllium and cadmium, and the PQL for chromium is higher (.5 compared to .05). Thus, it is still the case that none of the contaminants listed in the 401 certification are set to the lowest PQL identified in Ecology Memorandum # 3.

16. The fill source characterization testing protocol in the 401 Certification is not a technically defensible methodology to assure that the environmental fill criteria for the Third Runway Embankment Project will be met. As Peter Kmet of the Department of Ecology correctly points out in his e-mail of September 11, 2000 (copy attached as Exhibit C), a sampling program to evaluate the compliance of a site with MTCA or any other standards must meet a statistically acceptable confidence level. The number of samples required at a site should be dependent on the variability of the results. For example, six tests from a borrow site with 100,000 cubic yards of soil with little variability in the results may provide a confidence level of 95% that the fill meets the imposed criteria. However, at a site where six tests have significant variability in their results there may be no more than a 50% level of confidence that the criteria are being met. The current criteria are

ambiguous as to how many samples must fail the testing criteria to be excluded from the fill. Protocols should be in place consistent with MTCA (WAC 173-340-740) such that fill should not be accepted from a borrow source if 10% of the samples exceed the criteria or if any one sample exceeded the criteria by a factor of 2. The Third Runway Embankment project represents an ecologically sensitive project where the contaminant concentration levels of fill placed at the site should meet minimum confidence level criteria, such as the 95% confidence level discussed by Mr. Kmet. The testing protocol should be changed, particularly for large borrow sources, to provide a known level of confidence that the fill meets the environmental criteria. Without sufficient testing, contaminated fill could be placed leading to environmental impacts that will not be disclosed until after the fill is in-place and the impact has occurred. There are no intermediate checkpoints between placement of the fill and the measurement of the impact in the Creeks.

17. The Port argues that the Certification requires that the SPLP test be performed if the concentration of contaminants in the fill exceed the criteria and that this provides a higher level of assurance. This argument fails to recognize that the testing protocol is insufficient to evaluate whether the fill will meet the criteria and soils that should have been subjected to the SPLP test will not be tested and subsequently placed in the embankment. The acceptability of the fill based on the SPLP testing is uncertain. . A more appropriate testing and fill acceptance criteria would be that proposed by Kmet in his e-mail of September 11,2000 as discussed above.

18. The drainage layer under the embankment fill is in essence a blanket drain that collects the seepage through the fill. Without the drainage system the water would be

naturally dispersed into the underlying soils and groundwater. With the drainage system the water will be collected in the drainage system and diverted through channels and pipes to the creeks. The concentration of metals or organics in the water discharged from the embankment may be small but the volume of water will be large. The total mass of metals collected at the discharge point to the creeks will correspondingly be larger than would have occurred under conditions without the embankment in place. Over time, the concentration of metals in the creek sediments due to the concentrated discharge of the embankment drainage water will be larger than predicted assuming dispersion of the water seeping through the embankment. The Port's analysis fails to evaluate the ecological impact of this concentrated mass.

19. The September 401 Certification requires an 8 year monitoring period. The subsequent low flow analysis discussion supports a conclusion that the period of time for infiltration to pass through the embankment may be longer than originally predicted by the Port. Based on the uncertainty of the Ports low flow analyses, the monitoring period should be extended to at least 10 years or beyond.

LOW FLOW ANALYSES

20. The Low Flow analysis is flawed due to several oversimplifying assumptions that neglect the variability of the data. The first of these assumptions is that the discharge of water from the embankment will occur immediately after the completion of construction with no regard for the ability of the embankment to store water prior to discharging water into the gravel drain. This assumption ignores the fact that there will be a period of up to several years where the actual flows from the drain will be less than the predicted flows resulting in less available water to protect the low flow periods. The

second broad category of oversimplifying assumptions relates to the characterization of the soils in the embankment. The Port has assumed a uniform embankment with a singular set of hydraulic properties. The soils in the embankment will have a volume of approximately 20 million cubic yards. There is no chance that these materials will be uniform.

21. Water storage within the embankment during the first several years after construction will likely result in an inability of the Port to provide sufficient water from on-site sources for the low flow requirements during this time period. There appears to be no consideration given in the analysis to the time it will take between the end of construction of the embankment fill and the initial arrival of the predicted flows that have passed through the embankment and into the drainage layer.

22. The low flow analyses presented by the Port apparently encompass a ten-year rainfall record from 1984 to 1994. However, the first six years of the analysis results are not presented and the results after six years apparently represent the post-equilibration period. During the initial period, water entering the embankment would be absorbed by the fill and relatively little water would be released into the drainage layer for some unknown period of time. This time lag could be several years, and could lead to a requirement for a significantly greater volume of water to be stored in the vaults than predicted by the current analyses.

23. The largest storage requirements for water to protect the low flow conditions in the creeks will occur during the initial years following construction, when the flow through the embankment is likely to be most erratic and at its lowest volume. GeoSyntec has performed preliminary analyses using the Hydrus 2D model (presented in

more detail in a subsequent section of this statement) to evaluate the variability of the analyses. These analyses indicate that the initial lag time between completion of the embankment and arrival of water at the creek may be on the order of 1 year or more for a 20 ft high cross-section (shown on Figure 5-3 of the PGG report), 4 years or more for a 110 ft high cross-section (shown on Figure 5-2 of the PGG report) and 6 years or more for a 150 ft high cross-section (shown on Figure 5-1 of the PGG report). These delays would clearly have a severe impact on the creek low flows, yet the Port's current analyses do not appear to consider this critical scenario, even though they are modeling stretches of embankment fill of over 8000 ft in length, with 1600 ft represented by the 150 ft high embankment, 3700 ft represented by the 110 ft high embankment, and 3200 ft represented by the 20 ft high embankment (based on Table 5-7 of the PGG report).

24. The analysis by the Port relies on a single set of soil parameters to represent the behavior of 20 million cubic yards of fill that will be obtained from numerous different borrow sources. This is a gross oversimplification and will lead to significant discrepancies between the predicted streamflows and those that would actually occur after construction. The attached Figure 2 presents the range of soil grain sizes allowed by the project specifications and also presents the single grain size representation used in the low flow analyses. Fill placement during construction of the embankment will occur in horizontal layers. As a result, there will likely be large areas of fill with fine-grained, low hydraulic conductivity material that will control the rate at which water flows vertically through the embankment. The overall hydraulic conductivity of the actual soil in the embankment could be several orders of magnitude less than that assumed for the current low flow

analyses. This difference in hydraulic conductivity will have a substantial effect on the predictions made in the current analyses.

25. The Port has not considered the reliability of the unsaturated flow model used in the low flow analyses. The developers of the Rosetta model the Port uses in developing their unsaturated flow parameters for use in Hydrus, have stated: "Bootstrap analyses showed that the uncertainty in predicted unsaturated hydraulic conductivity was about one order of magnitude near saturation and larger at lower water contents."[4] This indicates that even if the material to be used was well defined (i.e. if there was only one source of material and it was of uniform characteristics) the uncertainties in the model would be greater than one order of magnitude (i.e. a factor of 10) for these analyses.

26. The current low flow analyses should not be accepted without a proper parametric evaluation of the influence of soil parameters on flow paths and travel times. A comparison of the soil parameters used for the low flow analyses and the range of soil types allowed for construction indicate that the flow rates through the embankment will be significantly more variable than the current analyses would indicate. That variability will likely increase the vault storage volumes required to protect low flow conditions in the creeks.

27. In Hart Crowser's "Embankment Infiltration and Seepage Studies" report[5], they presented unsaturated flow parameters and corresponding unsaturated behavior curves for three of the fill types proposed for the embankment (Group 1B, Group 3, and Group 4).

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[4] Schaap, M.G. and Leij, F.J. (2000) "Improved Prediction of Unsaturated Hydraulic Conductivity with the Mualem-van Genuchten Model," Soil Science Society of America Journal, Vol. 64, 843-851.

[5] Appendix C of the Hart Crowser "Geotechnical Engineering Analyses and Recommendations – Third Runway Embankment," prepared for HNTB, dated December 4, 2000, draft.

Figures 3a and 3b present the representative curves developed by Hart Crowser for the three fill types, along with the single set of curves being used presently by PGG in their Hydrus modeling (labeled "Port Properties"). Table 1 shows the input parameters used for each of the fill models. While Hart Crowser's modeling with the HELP program was overly simplistic and their method of accounting for gravel content was not well validated, their performance of parametric studies on the fill types was a step in the right direction compared to the single fill type currently being modeled in Hydrus. The Hart Crowser properties show that the hydraulic conductivity (which controls the rate at which water will pass through the fill) can range over several orders of magnitude for soils likely to be placed in the embankment. The figures clearly show that the single curve being used by the Port is not representative of the potential range of behavior.

28. In order to demonstrate the influence of the variability of soil properties on the lag time between embankment construction and first arrival of water at the drain, several simple cases were analyzed. 1-Dimensional columns of varying fill thickness (25 ft, 50 ft, 100 ft, and 150 ft) were modeled using Hydrus for three different sets of fill properties (Hart Crowser Group 1B, Hart Crowser Group 3, and the Port Properties). The 1-Dimensional columns were modeled in a fashion similar to the Port's analyses, where all infiltration was assumed to travel vertically through the fill, without an allowance for horizontal flow. Figure 4 shows the results of these analyses. A curve is shown for each set of properties, immediately revealing the potential for variability in the results. Each point on the curves represents the time between the beginning of the analysis (Day 0) when the precipitation record begins, and the time when the first water reaches the drain at the

base of the column. As the height of the 1-Dimensional column is increased (i.e. as the embankment fill thickness increases) the time lag increases relative to the properties for each fill type. For example, for a 50 ft fill thickness, the range of time lags shown is 250 to 500 days (approximately 0.7 to 1.4 years), and for a 150 ft fill thickness, the range is 850 to 2250 days (approximately 2.3 to 6.2 years). It will be shown later that ignoring the horizontal flow component in the fill (i.e. performing a 1-Dimensional analysis) results in an overestimation of the rate at which water flows through the fill, and thus the predicted lag times will actually be even longer than these values. In any case, the differences clearly demonstrate the potential variability in results, which the Port is ignoring in their analyses. Incorporation of this type of parametric study in the Port's analysis will likely have a significant impact on the design of the Port's low flow mitigation scheme and is absolutely necessary for proper representation of the possible impacts of the embankment fill.

29. The Port's selected method of ignoring the gravel content of the fill (which is assumed equal to more than half of the total mass) and adjusting the water inflows and outflows to compensate for this action is not a validated technique and may have significant impacts on the predicted versus actual flow paths and travel times. The Port's selected "representative" embankment fill material consists of 55% gravel, and 45% sand and silt. In order to model this material in Hydrus, they have made the following assumptions:

1. No flow will travel through the 55% gravel;

2. The entire embankment can be represented by a uniformly distributed material with properties corresponding to the remaining sand and silt matrix;
3. In order to mimic the corresponding rate of flow through the sand and silt, the amount of water entering the embankment can be increased by an amount that is proportional to the gravel content of the fill (i.e. multiplied by 2.22 = 1/0.45) and the amount of water exiting the embankment at the end of the analysis can be reduced by this same amount.

30. This approach is highly questionable as it in essence completely ignores the effect of the gravel on the unsaturated flow properties of the fill.

31. A review of available literature on the subject provides a more representative approach for modeling the fill that takes into account the influence of the gravel rather than ignoring it. In this approach, the Rosetta model is used with the sand and silt matrix to develop initial parameters. The residual and saturated moisture contents are then adjusted to account for gravel following the approach described and tested by Khaleel and Relyea (1997)[6], and the estimated saturated hydraulic conductivity is then adjusted following the approach described and tested by Brakensiek et al. (1986)[7]. By incorporating the influence of the gravel within the model parameters, there is no longer any need for artificial adjustment to the input precipitation values to Hydrus or to the predicted output discharges.

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[6] Khaleel, R. and Relyea, J.F. (1997) "Correcting laboratory-measured moisture retention data for gravels," Water Resources Research, Vol. 33, No. 8, 1875-1878, August 1997.

[7] Brakensiek, D.L., Rawls, W.J., and Stephenson, G.R. (1986) "Determining the saturated hydraulic conductivity of a soil containing rock fragments," Soil Science Society of America Journal, Vol. 50, 834-851.

32. While this approach presents a significant improvement over the simplified method used by the Port, it must also be taken in the context of the potential for variability among the parameters and the predictive capability of the model. The uncertainties of over an order of magnitude are still present. Therefore, this proposed approach should be calibrated by means of laboratory testing of representative samples of the embankment fill, and the analysis and subsequent design should not be based on a single set of parameters, but rather a representative range sufficient to bracket the likely behaviors of the embankment fill.

33. The Port's method of modeling of flow through the fill as a 1-Dimensional phenomenon using Hydrus is an oversimplification of a truly 3-Dimensional process, and will result in an overprediction of the rate at which water travels through the embankment. In addition to the Port's ignoring the gravel content of the embankment fill, their analysis consists of a series of 1-Dimensional columns of soil of varying thickness which force the infiltrating water to travel downward unimpeded without any lateral migration. Figure 5a shows a schematic of the system the port is actually modeling. Each column theoretically consists of 55% gravel and 45% sand and silt. However, water falling on any given column of soil is forced through the sand and silt matrix (achieved through artificial adjustment of precipitation and discharge quantities), bypassing the gravel completely. It should also be noted that water falling on the sloping face of the embankment is assumed not to infiltrate at all, and because the water can only travel vertically, this region never sees any water at all.

34. Figure 5b shows a schematic (which is still a simplification) of the type of layering that will exist in the embankment fill as a result of the construction process. 20,000,000 cubic yards of fill will be imported from numerous borrow sources and placed in horizontal layers at the then current elevation. The soil layers with the lowest hydraulic conductivity will control the vertical rate of flow of water traveling through the embankment. It will be impossible for the Port to control the fill sufficiently that an assumption of uniform flow behavior can be assumed realistically. The Port has failed to consider the very real variability of the soils that will be placed in the embankment. As a result of the fill layering, the flow path will be significantly more complex than represented

by the Port (e.g. Figure 5a), and the time for water to travel through the embankment will be much slower than predicted. Surface sloughing, which I observed on the slopes of the constructed embankment is evidence of the layering in the fill. The infiltrating water is being directed horizontally to the slope increasing the seepage emerging from the slope leading to the observed sloughing.

35. In addition to the flaws in the embankment fill modeling, the Port's modeling transition from Hydrus to SLICE and then to HSPF adds undesirable complexity and potential for error in the analysis. The multiple transitions between programs add significant potential for human error, as the data must be manipulated on several occasions as it is fed from one program to the next. This was seen previously in the Port's admitted error where flows were off by a factor of 24. The Port's consultants have not explained the rationales for this unnecessary complexity. GeoSyntec has performed preliminary analyses using the Hydrus 2D model in which the use of the SLICE model has been successfully eliminated from the analysis, as Hydrus is fully capable of modeling the flow into and through the drainage layer, as well as the flow into the underlying till.

Results of GeoSyntec Analysis

36. GeoSyntec is currently performing a detailed review of the Port's analysis, using the HYDRUS program to examine the sensitivity of the results to changes in input parameters. The purpose of this analysis is to evaluate the effect of the variability of the parameters in the analyses, not to recreate the Ports analyses. Table 2 presents the modeling criteria used by GeoSyntec for the preliminary analyses (fill properties were already shown in Table 1). Table 2 also includes the modeling criteria used by PGG for their analyses (where

available in their reports). While the analyses are ongoing, several important trends have been noted already.

37. Figure 6a presents a schematic of the Hydrus model cross-section being used by GeoSyntec, which is based on PGG's section 2, with an embankment fill height of up to 110 ft. The embankment fill, the drainage layer, the outwash layer, and the underlying till are all being modeled within Hydrus. The model is being run using approximately four years of daily precipitation data (January 1990 through February 1995) from the SeaTac airport. No runoff or evapotranspiration calculation has been made, so all precipitation is assumed to enter the embankment.

38. Figures 6a through 6e present preliminary results using the Hart Crowser Group 3 fill properties. The lighter colored front that progresses downward over time represents the propagation of the infiltrating precipitation. It is clear that the water infiltrating near the face of the slope, which has a shorter travel path to the drainage layer has already begun to reach the drain and then the creek by approximately 1 year after the modeling begins (Figure 6b). However, the flow under the thick majority of the embankment is only beginning to reach the drainage layer between 3 and 4 years (Figures 6d and 6e). With the uniform soil profile assumption relied upon by the Port, there is only slight evidence of horizontal flow of water, although Figures 6b through 6e show a gradual narrowing of the dark colored band of dry soil beneath the runway, indicating that moisture is gradually working its way laterally. This effect can also be seen in the flow of water between the filter strips on the right side of the model. The significance of this lateral flow component is that water will travel within the embankment fill for longer periods of time prior to reaching the

drain and the creeks than with analyses limited to vertical flow only. The Port, using their simplified analyses, has reported none of these trends.

39. To demonstrate the impact of horizontal flow on the travel time of water flowing through the embankment, two sets of analyses were performed using the Port's soil properties as shown on Figure 7. Two 25 ft thick fill columns were modeled in Hydrus, subjected to equivalent rainfall intensities. In the 1-Dimensional (1D) column, water infiltrating at the top of the column travels downward vertically, without an opportunity for any horizontal flow. In the 2-Dimensional (2D) column, water was applied over the middle $2/5^{ths}$ of the column only, but once the water entered the soil column, it was allowed to travel both vertically and horizontally. This 2-Dimensional scenario is representative of precipitation adjacent to the runway or filter strips (as seen on Figure 6), where water landing directly on the fill surface can pass directly into the embankment, but water landing on the impermeable runway or filter strips cannot.

40. Comparison of the 1D and 2D columns on Figure 7 makes the impact of horizontal flow immediately apparent. After 30 days, while flow in the 1D column has had nowhere to go but downwards (represented by the advancing dark colored wetting front), flow in the 2D column has traveled downwards and laterally (represented by the dark colored center and lighter colored bands spreading outwards both in front and on the sides of the wetting front). By 60 days, the wetting front in the 1D column has traveled approximately two thirds of the distance to the drain, while the 2D column wetting front has only progressed a quarter of the distance to the drain. This trend continues throughout the analysis, as the 1D column can only send water downwards, while the 2D column continues to allow water to fill

in underneath the impermeable regions on either side of the entry point. Clearly, without incorporating this effect into their analysis, the Port is overpredicting the rate at which water flows through the fill, and therefore their estimates of the time at which flows will arrive at the creek will not be representative.

41. While GeoSyntec's review is ongoing, I believe that the trends described are valid and will remain throughout the refined calculations presently under way. The implication of these results (i.e. the large lag time prior to initial arrival of water at the creek, the demonstrated influence of horizontal flow on travel times, and the influence of variability in the soil properties on travel times) is that the Port has underestimated the need for water to mitigate the low flow impacts to the Creeks, in particular in the first several years.

CONCLUSIONS

42. It has been shown that the fill screening criteria show inconsistencies and gaps in their development and implementation. The sampling protocol is insufficient to fully characterize large borrow sources and the criteria for acceptance of borrow material is not well defined. The alternative fill criteria allowed in the September certification is less protective of the environment with no supporting data or analyses for the changes from the August 401 requirements.

43. During the initial years following the completion of construction, the amount of water passing through the embankment into the underdrain is likely to be highly erratic and of a substantially lower quantity than the current low flow analysis predicts. The volume requirements of the storage vaults may be substantially under-designed. The under-design is due to the failure to calibrate the computer models being used; failure to

evaluate the variability of the embankment soils; and an over estimation of the overall hydraulic conductivity of the soils in the embankment by ignoring the basic flow processes that will be occurring. Based on the current low flow analysis it is impossible to predict whether the current vault sizes will be adequate on a long-term basis. During the initial years of operation it is probable that insufficient water will be available from the vaults to mitigate the impacts to low stream flows. Based on the uncertainty of the initial conditions in the embankment and the unsaturated hydraulic parameters, I recommend that a probabilistic low flow analysis be performed. Such analyses would allow the Port to understand the probability that additional sources of water may be required during the initial years following completion of construction.

Respectfully submitted,

Patrick C. Lucia, Ph.D.

Table 1: Comparison of Parameters Describing the Unsaturated Moisture Retention and Hydraulic Conductivity Functions for Hart Crowser and PGG Fill Materials.

	Parameter	**Hart Crowser Approach[1]** Group 1B	Group 3	Group 4	**PGG (2000)[2] Approach** Central Value
Input to Rosetta	Sand fraction	83.9	87.7		63
	Silt fraction	12.9	9.2		37
	Clay fraction	3.2	3.1		0
	Bulk Density (g/cm^3)	1.81	1.9		2
Output from Rosetta	Residual moisture content (θ_r)	Unclear. Could not completely replicate values reported in Hart Crowser (2000) using Rosetta.			0.0233
	Saturated moisture content (θ_s) (i.e. porosity)				0.2486
	Van Genuchten Alpha value (1/m)				8.77
	Van Genuchten n value				1.3472
	Saturated Hydraulic Conductivity (K_s) (m/d)				0.1169
Adjustment for Gravel		Bulk density value input into Rosetta was adjusted by a correction factor that accounts for the fraction of gravel.			Input to Hydrus (precipitation) is increased by a factor of 2.22 (1/0.45). Outflow from the embankment fill predicted by Hydrus is reduced by a factor of 0.45.
Values used in HELP or Hydrus	Residual moisture content (θ_r)	0.044	0.033	0.031	0.0233
	Saturated moisture content (θ_s) (i.e. porosity)	0.298	0.276	0.275	0.2486
	Van Genuchten Alpha value (1/m)	3.7	5.8	6.4	8.77
	Van Genuchten n value	2.434	1.548	1.255	1.3472
	Saturated Hydraulic Conductivity (K_s) (m/d)	2.592	0.3456	0.0605	0.1169

1 - Appendix C of the Hart Crowser "Geotechnical Engineering Analyses and Recommendations – Third Runway Embankment," prepared for HNTB, dated December 4, 2000, draft.

2 - PGG (Pacific Groundwater Group), "Sea-Tac Runway Fill Hydrologic Studies Report," June 19, 2000.

Table 2: Comparison of Numerical Parameters Used in One-Dimensional Simulations

Conditions	GeoSyntec Modeling	PGG (2001) Modeling
Nodal Spacing	0.1 ft vertical, 1 m horizontal	Vertical spacing discussed on pg 9 of PGG (2001). Vertical spacing was variable, with a minimum of 0.01 cm at the top, increasing to a maximum of 6 inches (0.5 ft) below a depth of 6 inches. Horizontal spacing: could not locate value in the PGG (2001) report.
Boundary Conditions	Top: Constant recharge with daily stress periods using average daily precipitation. Bottom: Constant pressure equivalent to the water table (pressure head = 0) Sides: no flow conditions	BCs described on pg 9 of PGG (2001) Top: Constant flux w/ daily stress period Bottom: "the bottom two nodes were assigned the 'water table' boundary conditions, which is a constant head boundary equal to elevation head, simulating saturated conditions beneath the embankment fill."
Initial Conditions	Pressure is in hydrostatic equilibrium with the water table positioned at lower boundary. The initial moisture content is determined by Hydrus from the specified initial pressure distribution. Generally there is a short capillary fringe. Above the capillary fringe the moisture content decreases with increasing height above the water, eventually approaching the residual moisture content.	Could not locate explicit description in the PGG (2001) report. In paragraph 4.5 (pg 9) they indicate that the initial moisture content is uniform, but do not provide a value.
Time Step Size	Initial time step = 0.1 days. Subsequent time steps are adjusted automatically by Hydrus based on the convergence rate, which is a function of the specified precipitation, and 4 user specified time step control parameters. Lower optimal iteration range = 3 Upper optimal iteration range = 7 Lower time step multiplication factor = 1.05 Upper time step multiplication factor = 0.7	Discussed on pg 9 of PGG (2001). Initial time step = 0.1 days. Could not locate a description of time step control parameters specified in their model runs.
Convergence Criteria	There are 3 user specified iteration control parameters: Maximum number of iterations = 20 Water content tolerance = 0.001 Pressure head tolerance = 0.001 m	Could not locate a description of iteration control parameters specified in their model runs.

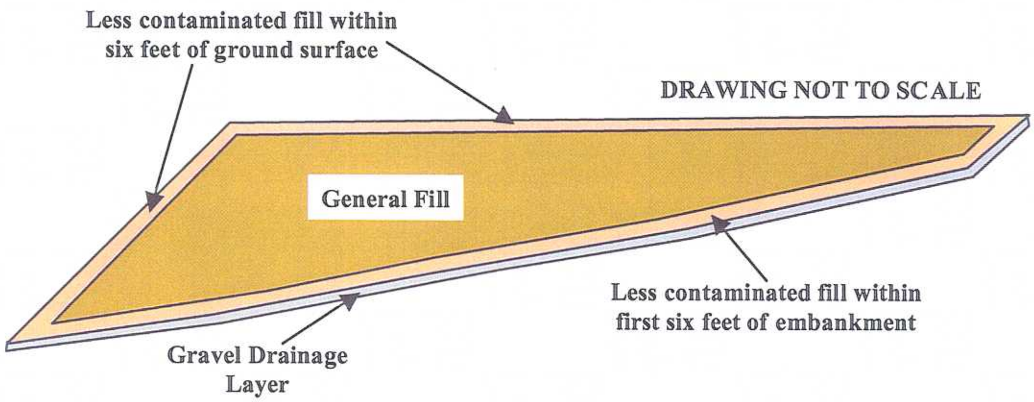


Figure 1a: Less Contaminated Fill Zone under August 401 Certification

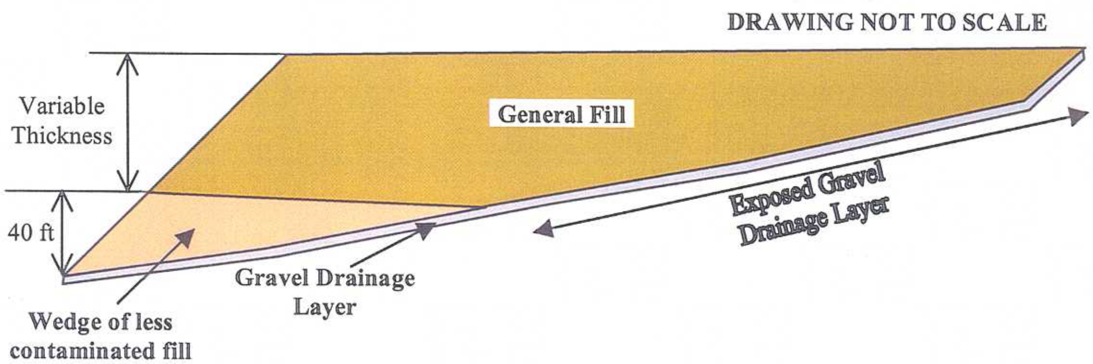


Figure 1b: Less Contaminated Fill Zone under September 401 Certification

Figure 2 - SeaTac Embankment Fill Grain Size Analysis

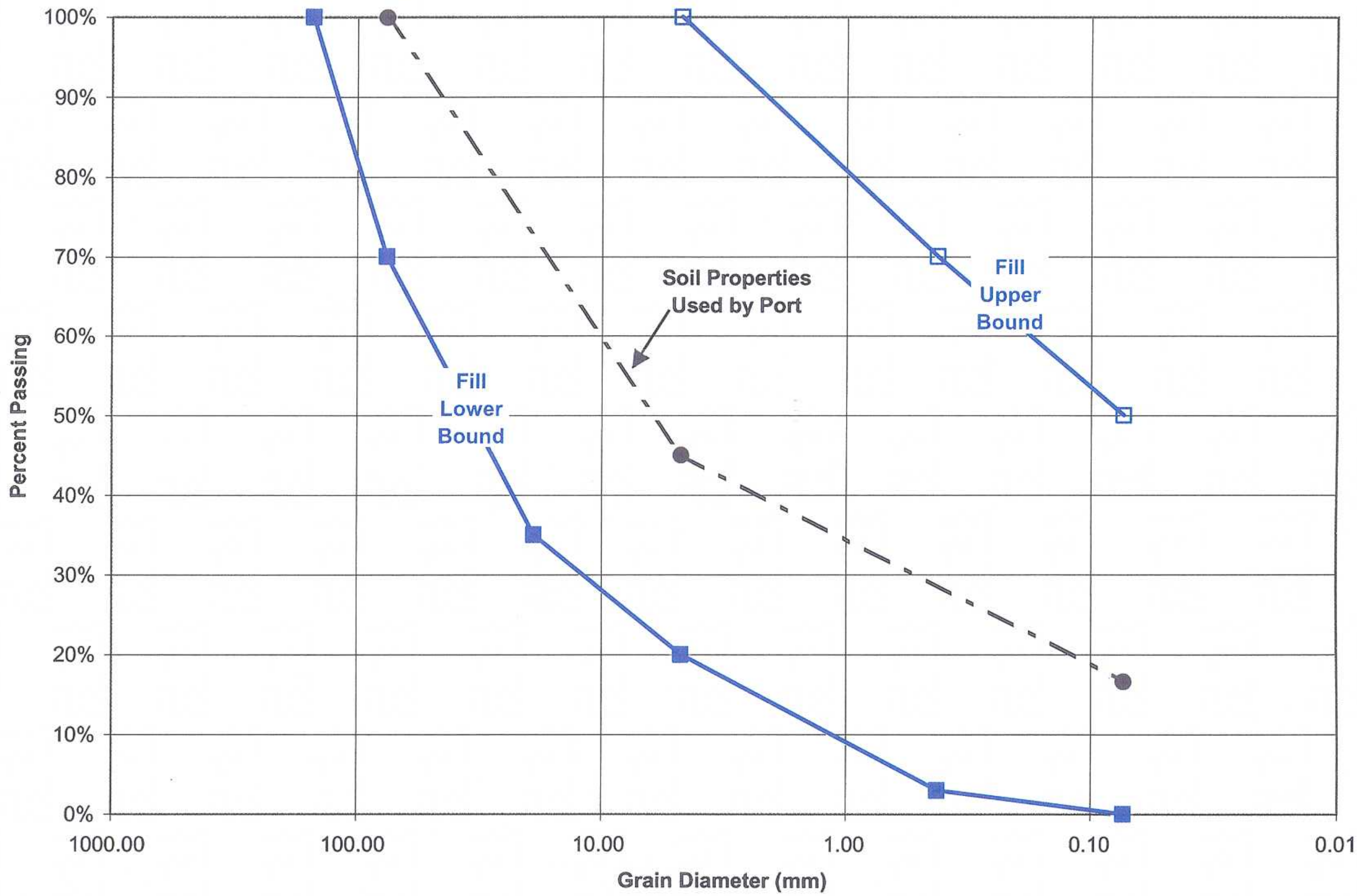


Figure 3a: Van Genuchten Parameter Variability

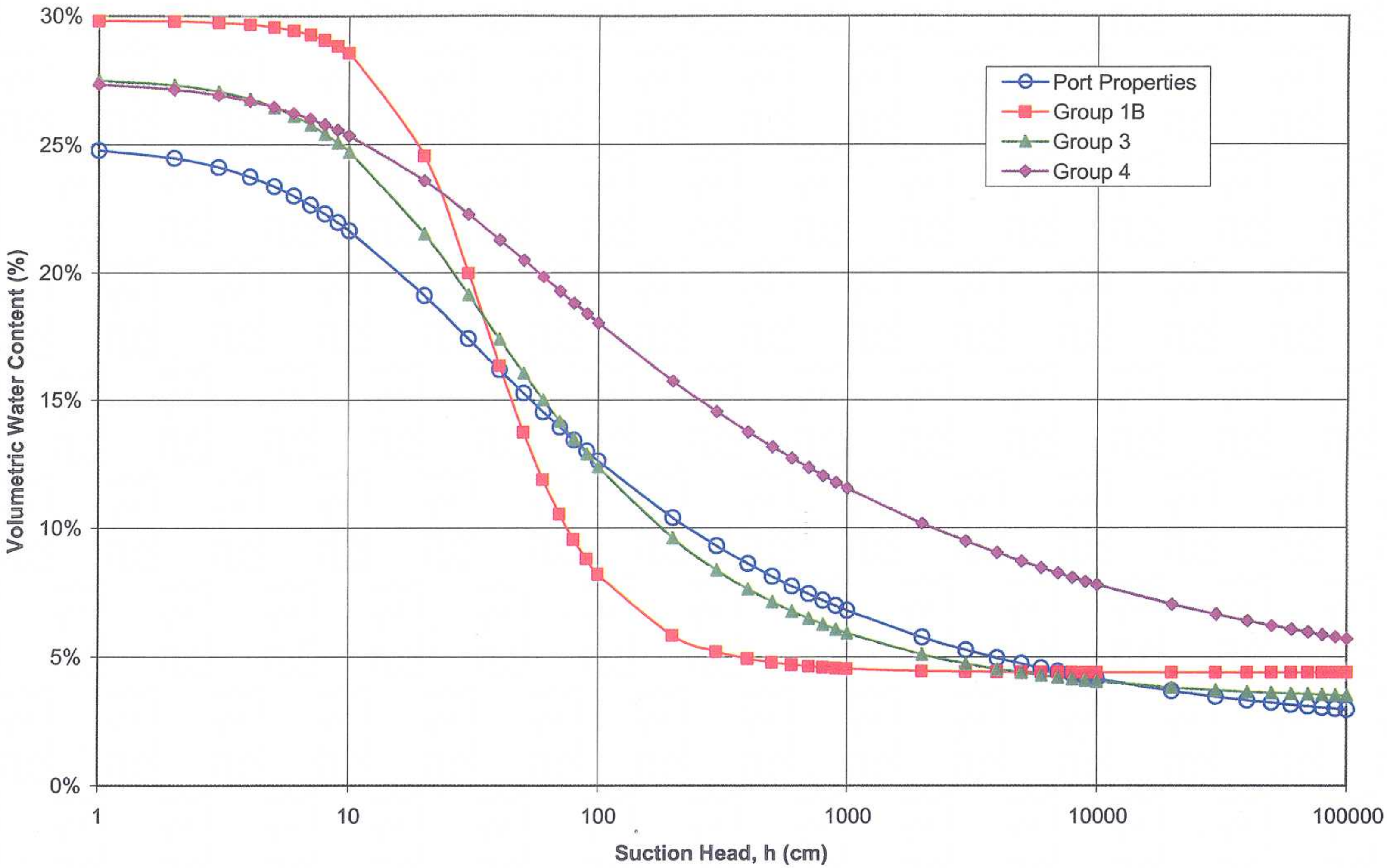


Figure 3b: Mualem Hydraulic Conductivity

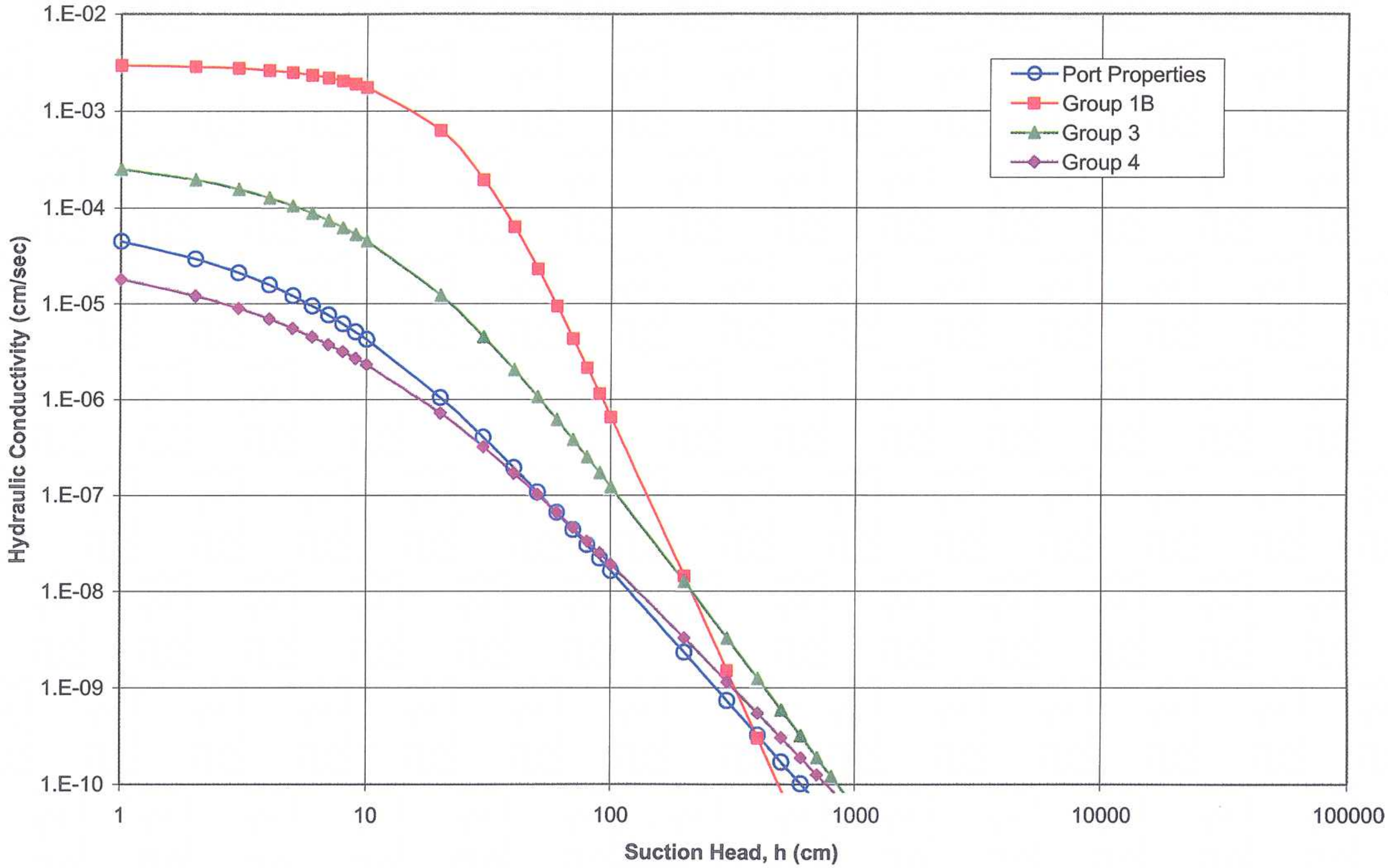
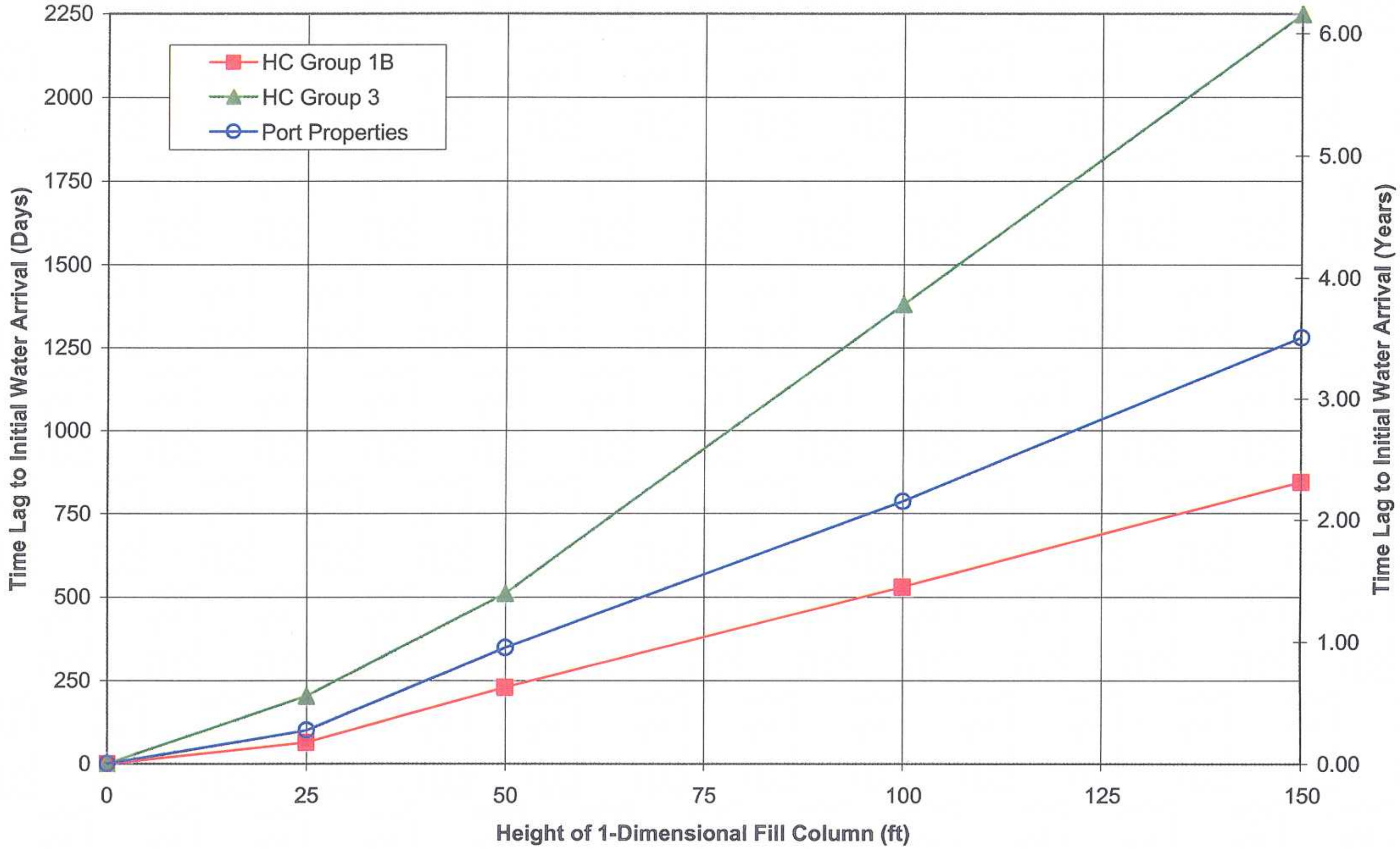


Figure 4: 1-Dimensional Column Initial Lag Times for Infiltration to Reach Drainage Layer under Varying Soil Properties and Column Heights



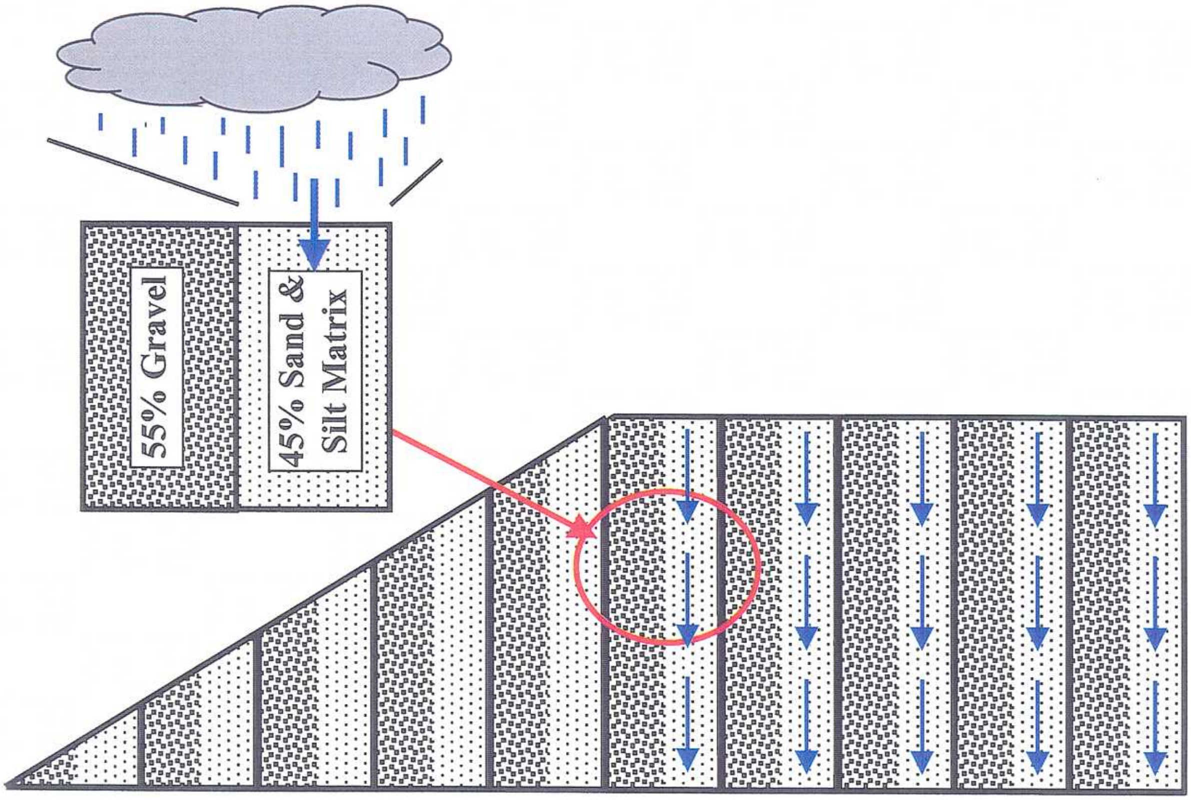


Figure 5a: Current Model System, all flow travels vertically through sand & silt matrix

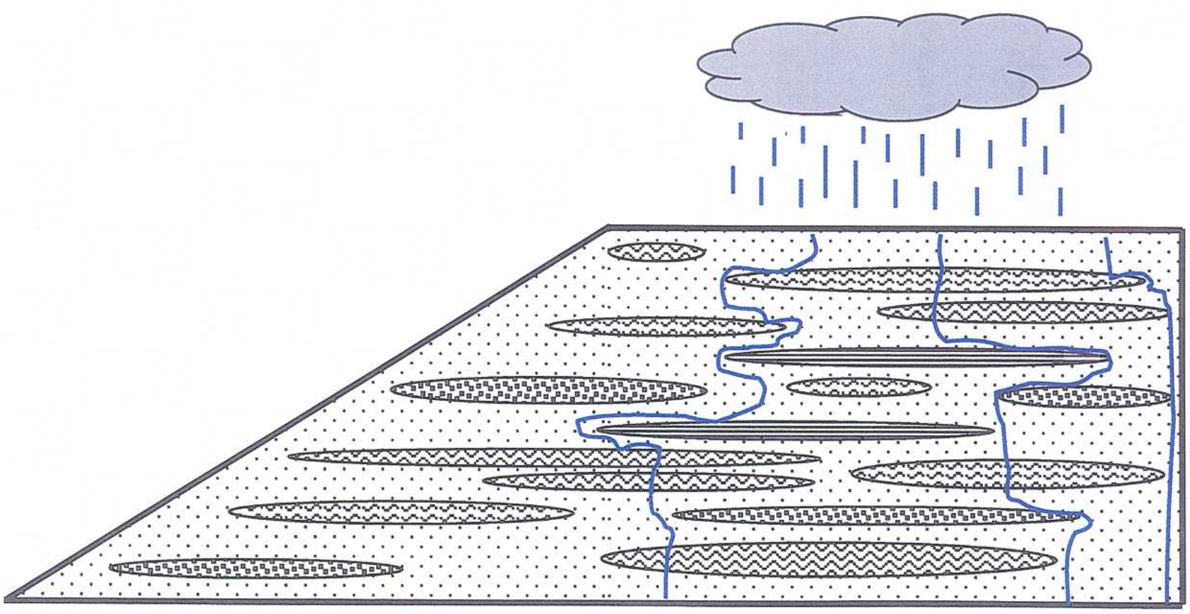


Figure 5b: More realistic scenario, flow paths change continuously throughout profile

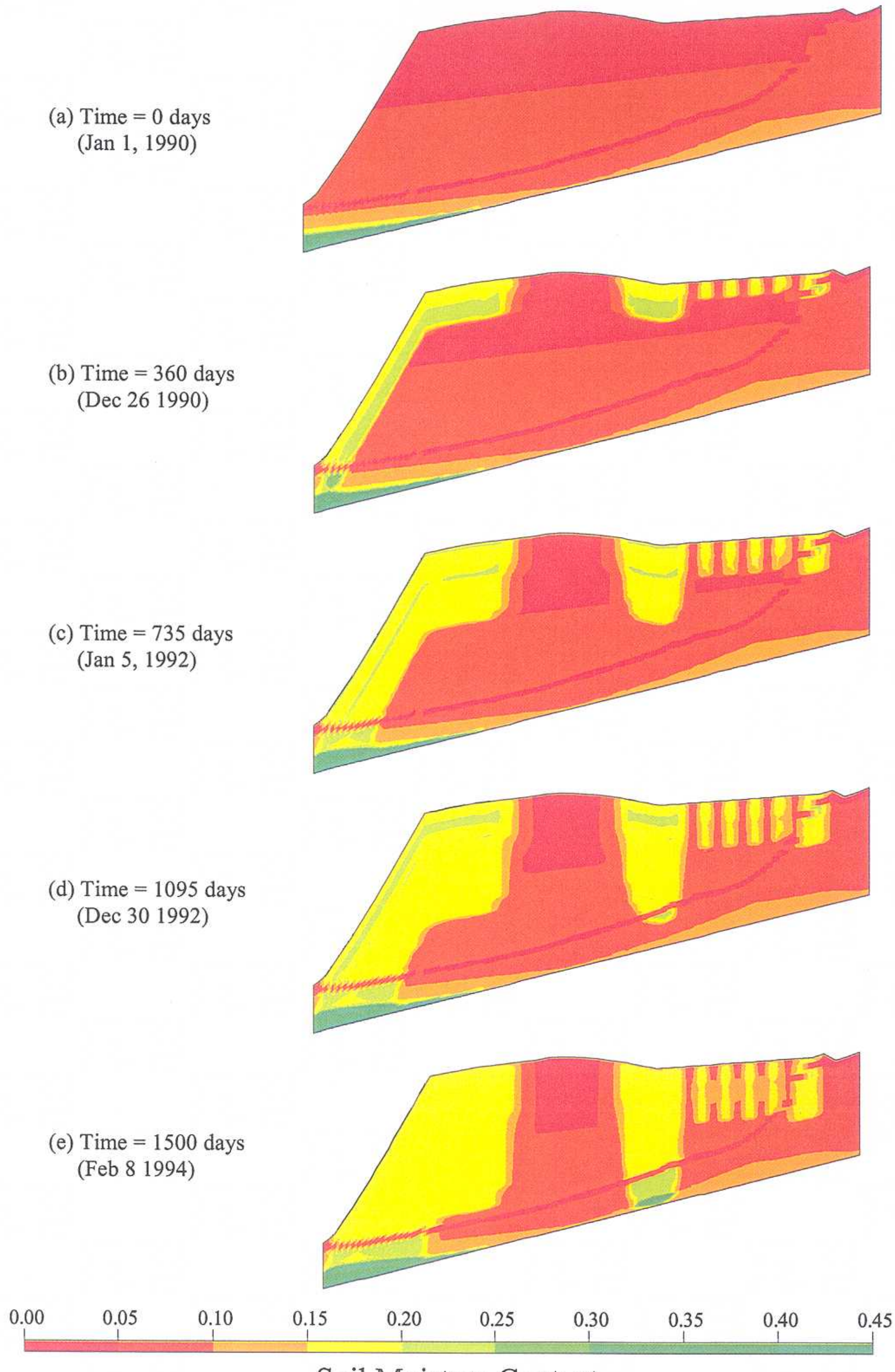


Figure 6: Moisture Content Variation Over Time for Cross Section 2
Using Hart Crowser Group 3 Embankment Fill Properties

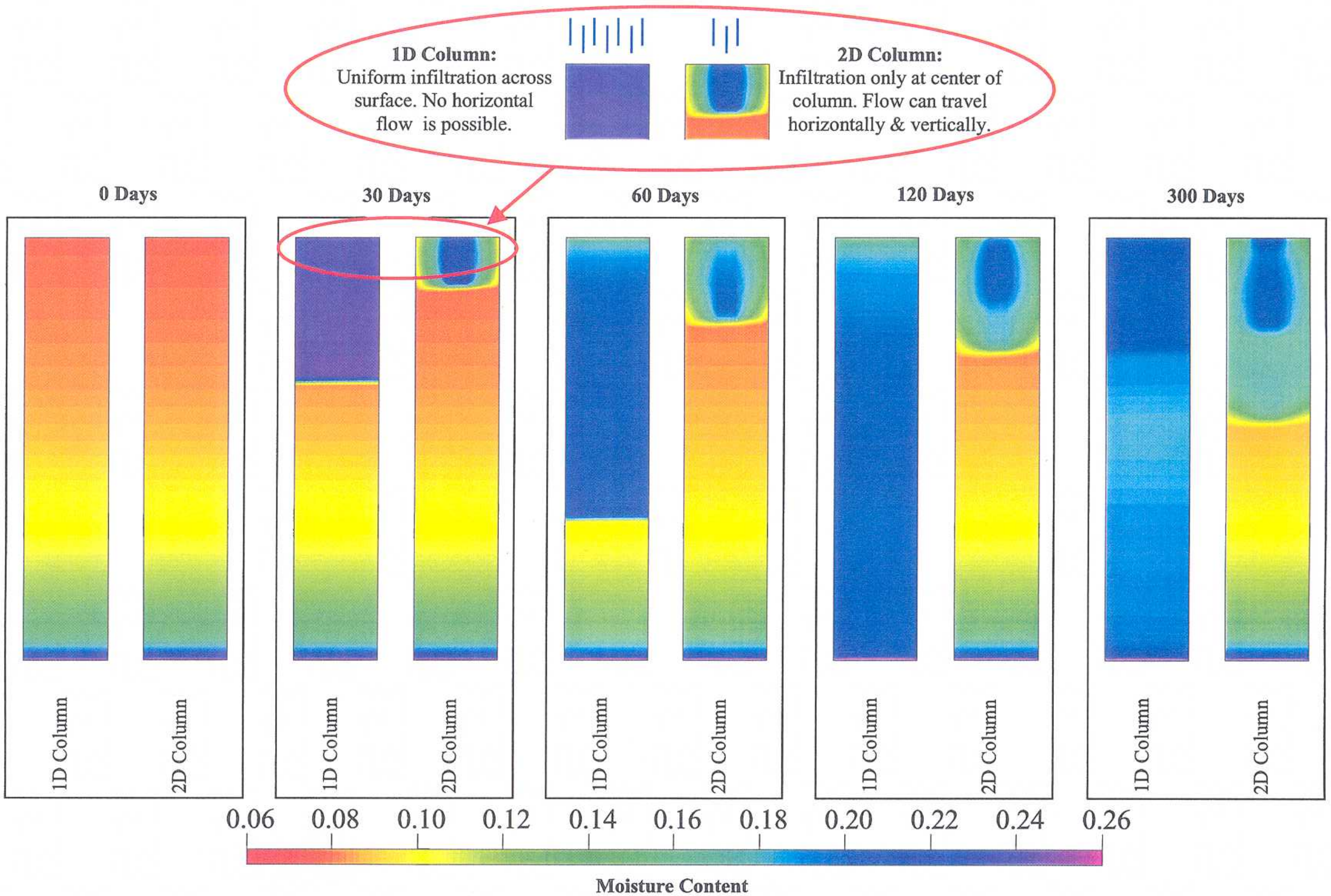


Figure 7: Comparison of 1-Dimensional versus 2-Dimensional Flow in Uniform Fill Columns (25 ft thick) with Port Properties

Pre-Filed Testimony
of
Dr. Patrick Lucia

INDEX TO EXHIBITS

A. Curriculum Vitae of Dr. Patrick Lucia

B. Department of Ecology Report dated November 24, 1993 from Steve Robb titled: "PQLs as Cleanup Standards"

C. Email from Pete Kmet to Kevin Fitzpatrick dated September 11, 2000 with attached document regarding Clean Fill Criteria for the 401 Water Quality Certification.

A

GeoSyntec Consultants

PATRICK C. LUCIA

geotechnical engineering
landslides
slope stability

EDUCATION

University of California: Ph.D., Civil Engineering, 1980
University of California: M.S., Civil Engineering, 1975
University of California: B.S., Civil Engineering, 1974

REGISTRATION

California Geotechnical Engineering (G.E.) Number GE2033
California Civil Engineer (P.E.) Number C33274

PROFESSIONAL HISTORY

GeoSyntec Consultants, Walnut Creek, California, Principal, 1993-Present
Woodward-Clyde Consultants, Principal and Vice President, 1984-1993
The Tensar Corporation, Pleasant Hill, California Western Regional Engineer, 1983-1984
Converse Consultants, San Francisco, California, Senior Engineer, 1980-1983
Geotechnical Engineers, Inc., Winchester Massachusetts, Senior Engineer, 1975-1977
Harding Lawson Associates, San Rafael, California, Engineer, 1974
United States Army Corps of Engineers, 1966-1969

ACADEMIC APPOINTMENTS AND INVITED LECTURES

NATO Advanced Study Institute on Groundwater Pollution Control and Remediation, Invited Lecturer, Kemer, Antalya, Turkey, 1995
National Groundwater Association, In-situ Remediation Course, Lecturer, 1994-1995
American Society of Civil Engineers, San Francisco Section, Remediation/Clean-up of Soil and Groundwater Contamination, Spring 1994 Seminar, Invited Lecturer
Georgia Institute of Technology, 1994 Monie A. Ferst Symposium, Invited Lecturer
University of Wisconsin, Slope Stability Short Course, Lecturer, 1994
University of Wisconsin, In-situ Remediation Short Course, Lecturer, 1993-1994

University of California, Berkeley Extension Program, Member of Advisory Panel on the Certification Program in Remediation, 1992

University of California, Davis, Senior Lecturer, 1990-1991

The Application of United States Pollution Control Technology in Korea, Invited Lecturer, Seoul, Korea, 1989

University of California, Berkeley, Adjunct Lecturer, 1986; Visiting Lecturer, 1984-1986; Research Engineer, 1978-1980; Teaching Assistant, 1977-1978

OTHER APPOINTMENTS

San Francisco Bay Conservation and Development Commission, Engineering Criteria Review Board, 1985 to 1996

REPRESENTATIVE EXPERIENCE

Dr. Lucia is a civil engineer specializing in the areas of geotechnical engineering and waste management. During more than 25 years of professional practice, he has been responsible for directing a broad range of projects requiring knowledge of foundation and earthquake engineering. Dr. Lucia has worked at various facilities ranging from industrial commercial sites to power plants, and has negotiated with federal, state, and local agencies. In addition, he provides litigation support on environmental and geotechnical matters, and has provided depositions and testimony at trial.

REPRESENTATIVE PROJECT EXPERIENCE

- As a member of the San Francisco Bay Conservation and Development Commission Engineering Criteria Review Board, Dr. Lucia served as reviewer for the repairs and upgrade of the Benicia Bridge and the Richardson Bay Bridge. Dr. Lucia also served as reviewer of the seismic analyses and subsequent repairs of the Golden Gate and Bay Bridges following the 1989 Loma Prieta earthquake.

- Investigation and development of recommendations for repair of a 200-foot deep landslide at the Keller Canyon Landfill in Pittsburgh California. Mitigation included construction of a toe buttress and unloading of the head of the landslide requiring the movement of over one million cubic yards of soil.

- Investigation and design of the repair of the San Pablo landslide. Mitigation included installation of horizontal drains up to 600 feet long, excavation and compaction of over one million cubic yards of soil, buttresses up to 120 feet high, drilled piers up to 3 feet in diameter and 60 feet deep, and construction of a 40-foot high, 900-foot long Tensar reinforced earth wall.

- Served as Project Manager for the geotechnical investigation and development of recommendations for lateral earth pressures in a deep excavation, foundation preparation, and handling of contaminated soil and groundwater at a major medical facility in San Francisco, California.

- Provided geotechnical analysis and support to Panama Canal Commission to address landslides that have occurred during the widening of the Panama Canal.

- Foundation investigation and recommendations for the Napa County Courthouse.

- Evaluation of settlement and stability of a proposed shoreline development in Vallejo, California.

- Investigation and development of recommendations for roadway widening in Concord, California.

- Investigation and development of recommendations for sanitary sewer installation and development of a training program for inspectors for the Central Contra Costa Sanitary District.

- Evaluation of building settlement in San Francisco, California.

- Numerous landslide repairs for Marin County Department of Public Works.

- Developed recommendations for the installation of a slurry wall and dewatering system at the Pilgrim Nuclear Power Plant, Plymouth, Massachusetts.

- Evaluated the static and seismic stability of the East Bay Municipal Utilities District's (EBMUD) Mokelume Aqueducts in the San Joaquin Delta region of California.

- Evaluation of the static and seismic stability of EBMUD's Summit Reservoir.

- Developed plans and specifications for five miles of erosion protection at Pacific Gas & Electric Company's Bass Lake Reservoir in Northern California.

- Siting study, site characterization, and preparation of preliminary plans, specifications, and cost estimates for four (4) landfill sites in Sonoma County, California.
- Site characterization, preparation of plans and specifications for the proposed 600 foot high Kirker Pass Landfill, Contra Costa County, California.
- Provided review and testimony before the State Water Resources Control Board on the stability of the Keller Canyon Landfill, Contra Costa County, California.
- Design of a geosynthetic reinforced buttress to stabilize portions of the Operating Industries Landfill in Monterey Park, California.

REPRESENTATIVE LITIGATION SUPPORT

- On behalf of counsel for a geotechnical engineering firm, provided expert testimony in deposition and trial for litigation involving the Discovery Bay residential development in the San Joaquin Delta region of California. Testimony concerned the cause of slope settlement and the engineers' compliance with the Standard of Care.
- Provided expert testimony in deposition and trial on the probability of failure and potential remediation costs for over 20 landslides at the Rancho Solano development in Fairfield, California.
- Provided expert testimony in deposition for litigation involving a major landslide at a housing development in San Ramon, California. Testimony concerned the cause of failure, and the geotechnical engineer's compliance with the Standard of Care.
- Provided expert testimony in deposition and in arbitration for a $3.5M claim concerning the cause of failure of several retaining structures in the geysers area of Northern California. Addressed contractor compliance with plans and specifications.
- Provided expert testimony representing the contractor in depositions and in arbitration in a $2.5M claim relative to the cause of pipeline settlement and contractor compliance with plans and specifications for a project in Pleasanton, California.
- Provided expert testimony in nonbinding arbitration in a $250,000 changed condition claim representing the contractor in a pipeline construction project in Santa Clara County.

- Provided expert testimony in deposition and trial in San Mateo County representing a homeowner regarding settlement of a building due to construction adjacent to the property.

- Provided litigation support representing the developer of a condominium project in Contra Costa County. Evaluated the cause of settlement, probable mitigation alternatives and cost of foundation repair of the buildings.

- Provided litigation support to a geotechnical engineering firm regarding settlement of numerous buildings in a condominium project in San Mateo County. Evaluated cause of settlement, amount of settlement remaining over the next 30 years and reasonable mitigation alternatives.

- Currently providing litigation support for cost allocation and the likely sources of PCE and TCE in groundwater on behalf of counsel representing a manufacturing facility in Mountain View, California.

- Provided expert testimony in deposition on the allocation of cost and closure alternatives for a landfill with an extensive volatile organic compound (VOC) contaminated groundwater plume in Ventura County, California.

- Served as a member of the Board of Consultants charged with reviewing the closure design for a hazardous and low-level radioactive waste landfill including stabilization and closure of surface impoundments, in West Chicago, Illinois. Provided expert testimony in trial and in hearings before the Nuclear Regulatory Commission.

- On behalf of counsel to a potentially responsible party (PRP), provided expert testimony in trial on causes of lead contamination at the Point Isabel site in Richmond, California.

- Provided expert testimony in deposition and mediation on alternatives and remediation costs at a site in Sacramento, California, contaminated with over 700 cubic yards of battery casings.

- Provided expert testimony in deposition on remedial alternatives and remediation costs concerning a lead-contaminated site in San Francisco, California.

- On behalf of counsel representing municipalities, provided review and expert testimony in deposition on the remediation, closure methods, and estimated cost of closure for a Class II landfill in Richmond, California.

AFFILIATIONS

American Society of Civil Engineers
Society of American Military Engineers
Tau Beta Pi
Phi Beta Kappa

RECENT PUBLICATIONS

"*Evaluation of Remedial System and Strategies*", Invited paper presented at the NATO Advanced Study Institute on Groundwater Pollution Control and Remediation, Turkey, 1995.

"*Design of Landfills*", Invited paper presented at the Application of U.S. Pollution Control Technology in Korea, Conference on Solid and Hazardous Waste Technology, Seoul, Korea, 1989.

"*Application of GeoSynthetics in Waste Management*", Invited paper presented at the Application of U.S. Pollution Control Technology in Korea, Conference on Solid and Hazardous Waste Technology, Seoul, Korea, 1989.

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DEPARTMENT OF ECOLOGY

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November 24, 1993

Implementation Memo No. 3

TO: Interested Staff

FROM: Steve Robb

Toxics Cleanup Program

SUBJECT: PQLs as Cleanup Standards

ISSUES

Two issues have been raised with regard to the use of practical quantitation limits (PQLs) in setting cleanup levels:

- The "legal" issue of PQLs as cleanup levels and whether or not PLPs have any long-term liability for sites cleaned up to the PQL level rather than the risk-based level. Can PLPs receive a covenant not to sue in these situations? Are they required to utilize institutional controls and conduct long-term monitoring?
- When risk-based compliance values are less than PQLs, what value is used in the risk summation calculation, the risk-based value or the PQL?

I. LONG-TERM LIABILITY

The Model Toxics Control Act (MTCA) states, "Where cleanup levels are below the PQL, compliance with cleanup standards will be based upon the PQL" (WAC 173-340-700(6) Measuring compliance). Also stated in the rule, "If those situations arise and the practical quantitation limit is higher than the cleanup level for that substance, the cleanup level shall be considered to have been attained, subject to subsection (4) of this section..." (WAC 173-340-707(2) Analytical considerations). Therefore, the PQL becomes the compliance value, and PLPs who attain the PQL are eligible for a covenant not to sue. WAC 173-340-707(4) places one additional burden, however, and that is a requirement for periodic review of the cleanup action in which the department, in reviewing the cleanup action, shall "...consider the availability of improved analytical techniques." Therefore, any covenant must have a reopener which would allow the department to take action if necessary.

Long-term monitoring is not required as long as the remedy does not specifically involve containment. However, it is possible that the remaining unquantified risk at a site could be sufficient to cause concern. This situation makes it very important for project managers to require PLPs to attempt to quantify those contaminants which have high PQLs. We need to avoid situations in which PLPs may leave unquantified contamination and that upon periodic review new analytical data demonstrates that further action is necessary. The rule supports the use of special analytical methods and/or institutional

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controls to address this situation.

WAC 173-340-707(3) gives project managers the flexibility to require special sampling and analytical methods. PQLs should not be used to justify unnecessarily high compliance levels. In cases where the risk-based cleanup level is less than the PQL, site managers should calculate, using the appropriate formula, the risk the contaminant would represent if it were present at the PQL concentration. As this risk approaches the 1x10-5 level, serious consideration should be given to use of surrogate measures of the hazardous substance or development of specialized sample collection and/or analysis techniques. If the risk posed by a contaminant concentration at the PQL level exceeds the 1x10-5 level, project managers should consider requiring special analytical methods which can quantify the contaminant concentration at least to the 1x10-5 level.

In support of this approach, the Responsiveness Summary (RS) acknowledges that in meeting its mission to protect human health and the environment, Ecology cannot ignore concentrations below current quantitation limits. In doing so, the RS states, we would be placing "...human health and the environment 'at the mercy of analytic quantitation limits' and would be inconsistent with the statute's overriding objectives" (p. 107).

Finally, WAC 173-340-440(1)(a) requires institutional controls "...when the department determines such controls are required to assure the continued protection of human health and the environment or the integrity of the cleanup action." In situations where the PQL is above cleanup levels (i.e. exceed the 1x10-5 level), project managers should evaluate the need for institutional controls, particularly if special analytical methods are inadequate.

II. RISK SUMMATION CALCULATIONS BASED ON PQLs

MTCA requires the development of cleanup levels that are protective of human health and the environment. For carcinogenic substances, protection is defined as a cumulative site risk that does not exceed 1 in 100,000 (1x10-5). However, our inability to reliably measure some contaminant concentrations at calculated risk-based levels hinders our ability to measure total site risk.

In some situations the risk posed by a single contaminant at the PQL concentration outweighs the risk of all the other contaminants put together. Using such a PQL risk value in the risk summation calculation will negate the usefulness of both the risk summation and the 1x10-5 cumulative site risk requirement. In this situation, to calculate overall site risk, use the risk-based cleanup level rather than the PQL. The other contaminant concentrations can then be adjusted downward, as necessary, so the adjusted total site risk does not exceed 1x10-5. The final list of compliance levels should show the single contaminant at the PQL value and the other contaminants at their adjusted levels.

When adjusting individual cleanup levels to meet the one in a hundred thousand total risk standard at sites with multiple contaminants becomes necessary, do not adjust a contaminant below its PQL. For example, the cleanup level for trichloroethylene (TCE) in groundwater is 3.98 ppb and the PQL is 0.5 ppb. If higher cleanup levels for other compounds required the TCE cleanup level to be adjusted downward, it should not be adjusted below 0.5 ppb.

One final clarification regarding risk summation is warranted. Method B specifically establishes cleanup levels based on a risk of one in a million for individual carcinogenic contaminants. When multiple contaminants and/or multiple pathways of exposure are involved, MTCA allows for a cumulative site risk of no more than one in a hundred thousand (e.g., WAC 173-340-720(5)). The one in a hundred thousand risk level is intended to serve as a cap, or ceiling, on the cumulative site risk at cleanup sites with multiple contaminants and is not a goal.

For example, when the cumulative site risk total is 8x10-5, cleanup levels for individual constituents must be adjusted downward until the cumulative site risk is equal to or less than 1x10-5. Alternately, at sites where the total cumulative site risk is 8x10-6, for example, no downward adjustment is necessary, since the risk does not exceed 1x10-5. However, adjustment upward for individual contaminants is not permitted under MTCA since individual contaminants must still meet the 1x10-6 (or 1x10-5 for Method C) limit.

Risk Communication

How we portray risk to the public is important to the implementation of the rules. When cleanup levels are based on PQL values, Ecology site managers should explain that technical limitations may prohibit us from measuring contaminants at levels that correspond to a risk of 1x10-6. This explanation should be part of the Cleanup Action Plan (CAP) and any public hearings where cleanup levels and risk are discussed. The CAP should include a list of risk-based levels as well as a list of the compliance levels.

Analytical Guidelines

- Know your expected PQLs. Communicate with your laboratory if you have any doubts, special expectations, or special analytical needs. Before your analytical work is requested, be sure that the results to be provided by your laboratory will meet your requirements.
- With the analytical results, the estimates of the PQLs for each sample matrix along with an explanation of how the PQL was determined should be provided by the laboratory.
- Appropriate quality assurance and quality control (QA/QC) data should be provided by the laboratory for all sets of samples.

What Are The PQLs?

There is no definitive list of PQLs. However, Ecology has put together tables of PQLs, MDLs (method detection limits), and comparisons to Method B numbers for groundwater, surface water, and soil. These tables are based on surveying published methods and laboratories. There are many factors that can produce a different PQL for one sample as compared to another. However, these tables can be useful guidance. Ecology refers you to the guidance for the use of the tables and also to a discussion on the meaning of PQLs. These are found as three additional parts to this memorandum. The four parts are:

Part I: Implementation Memo No. 3--PQLs as Cleanup Standards (this document)

Part II: Guidance For The Use of Tables

Part III: MDL, PQL, and Comparisons Tables

NOTE TO USERS: The following links on this page are to Microsoft Excel documents. Windows users who do not have Microsoft Excel may view and print these documents with Excel Viewer *which is available to download via FTP from Microsoft. Please note: the downloadable documents are not available for either Macintosh or Unix systems.*

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TABLE II: SOIL										
MDLs, PQLs, and Comparison of Method B Values										
		☜	Lab PQL Range < Published PQL							
CAS	Chemical	Method	Dectector	PQL (mg/kg)	☜	LABORATORY PQL RANGE (mg/kg)			10e-6 Method B Soil Value (mg/kg)	💣 PQL > Soil Method B (flag=na)
83-32-9	acenaphth	8270	GC/MS	0.66		0.013	-	0.66		
83-32-9	acenaphth	8310	HPLC	1.2		0.017	-	1.2		
208-96-8	acenaphth	8270	GC/MS	0.66		0.017	-	0.66	n/c	⚐
208-96-8	acenaphth	8310	HPLC	1.5		0.017	-	1.5	n/c	⚐
67-64-1	acetone	8240	GC/MS	0.01		0.001	-	0.05		
107-02-8	acrolein	8030	GC-FID	0.007		0.001	-	0.01		
79-06-1	acrylamide	8015	GC-FID						2.22E-1	
107-13-1	acrylonitri	8030	GC-FID	0.005		0.001	-	0.05	1.85E+0	
5972-60-8	alachlor	505.2	GC-ECD	0.01					1.23E+1	
116-06-3	aldicarb	531.1	HPLC	0.5						
309-00-2	aldrin	8080	GC-ECD	0.003		0.0017	-	0.003	5.88E-2	
62-53-3	aniline	8270	GC/MS	0.66		0.067	-	0.66	1.75E+2	
120-12-7	anthracen	8270	GC/MS	0.66		0.017	-	0.66		
120-12-7	anthracen	8310	HPLC	0.009		0.005	-	0.009		
7440-36-0	antimony	6010	ICP	16	☜	1.5	-	10		
7440-36-0	antimony	7041	AA	1.5		0.00025	-	1		
140-57-8	aramite	8270	GC/MS						4.00E+1	
2674-11-2	Aroclor 10	8080	GC-ECD	0.044		0.017	-	0.1		
1104-28-2	Aroclor 12	8080	GC-ECD	0.044		0.017	-	0.1	n/c	⚐
1141-16-5	Aroclor 12	8080	GC-ECD	0.044		0.017	-	0.1	n/c	⚐
3469-21-9	Aroclor 12	8080	GC-ECD	0.044		0.017	-	0.1	n/c	⚐
2672-29-6	Aroclor 12	8080	GC-ECD	0.044		0.017	-	0.1	n/c	⚐
1097-69-1	Aroclor 12	8080	GC-ECD	0.088		0.017	-	0.1	n/c	⚐
1096-82-5	Aroclor 12	8080	GC-ECD	0.088		0.017	-	0.1	n/c	⚐
7440-38-2	arsenic	6010	ICP	25	☜	2.5	-	10	1.43E+0	💣
7440-38-2	arsenic	7060	GFAA	0.5		0.00025	-	0.5	1.43E+0	
7440-38-2	arsenic	7061	GHAA	1					1.43E+0	
1332-21-4	asbestos									
1912-24-9	atrazine	619	GC/NP	0.05					4.55E+0	
103-33-3	azobenzen	8270	GC/MS	0.33		0.033	-	0.33	9.09E+0	
56-55-3	benz[a]an	8270	GC/MS	0.66		0.0055	-	0.66	1.37E-1	💣
56-55-3	benz[a]an	8310	HPLC	0.009		0.005	-	0.009	1.37E-1	
71-43-2	benzene	8020	GC-PID	0.002		0.001	-	0.04	3.45E+1	
71-43-2	benzene	8240	GC/MS	0.005		0.001	-	0.01	3.45E+1	
92-87-5	benzidine	8250	GC/MS	29		0.8	-	29	4.35E-3	💣
50-32-8	benzo[a]p	8270	GC/MS	0.66		0.005	-	0.66	1.37E-1	💣
50-32-8	benzo[a]p	8310	HPLC	0.015		0.005	-	0.015	1.37E-1	
205-99-2	benzo[b]fl	8270	GC/MS	0.66		0.005	-	0.66	1.37E-1	💣
205-99-2	benzo[b]fl	8310	HPLC	0.012		0.005	-	0.012	1.37E-1	

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191-24-2	benzo[g,h	8270	GC/MS	0.66		0.01	-	0.66	n/c	⚐
191-24-2	benzo[g,h	8310	HPLC	0.051		0.01	-	0.051	n/c	⚐
207-08-9	benzo[k]fl	8270	GC/MS	0.66		0.005	-	0.66	1.37E-1	💣
207-08-9	benzo[k]fl	8310	HPLC	0.011		0.005	-	0.011	1.37E-1	
65-85-0	benzoic ac	8270	GC/MS	3.3		0.1	-	3.3		
98-07-7	benzotrich	8270/8010	-MS/GC-H	0.05		0.05	-	0.33	7.69E-2	
100-51-6	benzyl alc	8270	GC/MS	1.3		0.033	-	1.7		
100-44-7	benzyl chl	8240	GC/MS	0.1		0.1	-	0.33	5.88E+0	
7440-41-7	beryllium	6010	ICP	0.15		0.125	-	0.25	2.33E-1	
7440-41-7	beryllium	7091	GFAA	0.1		0.125	-	0.25	2.33E-1	
111-91-1	bis(2-chlo	8270	GC/MS	0.66		0.033	-	0.66	n/c	⚐
111-44-4	bis(2-chlo	8270	GC/MS	0.66		0.017	-	0.66	9.09E-1	
9638-32-9	bis(2-chlo	8270	GC/MS	0.66		0.067	-	0.66		
117-81-7	bis(2-ethy	8270	GC/MS	0.66		0.017	-	0.66	7.14E+1	
542-88-1	bis(chloro	8270	GC/MS	0.66		0.01	-	0.66	4.55E-3	💣
75-27-4	bromodich	8010	GC-Hall	0.001		0.001	-	0.1	1.61E+1	
75-27-4	bromodich	8240	GC/MS	0.005		0.001	-	0.01	1.61E+1	
75-25-2	bromoform	8010	GC-Hall	0.002		0.001	-	0.5	1.27E+2	
75-25-2	bromoform	8240	GC/MS	0.005		0.001	-	0.01	1.27E+2	
101-55-3	bromophe	8270	GC/MS	0.66		0.017	-	0.66	n/c	⚐
85-68-7	butyl benz	8060	GC-FID	10						
85-68-7	butyl benz	8270	GC/MS	0.66		0.033	-	0.66		
85-68-7	butyl benz		GC-ECD	0.23						
7440-43-9	cadmium	6010	ICP	2	☝	0.01	-	1		
7440-43-9	cadmium	7130	GFAA	0.05		0.05	-	0.25		
86-74-8	carbazole	8270	GC/MS	0.33					5.00E+1	
1563-66-2	carbofuran	632	HPLC	0.83						
75-15-0	carbon dis	8240	GC/MS	0.1	☝	0.001	-	0.05		
56-23-5	carbon tet	8010	GC-Hall	0.001		0.001	-	0.01	7.69E+0	
56-23-5	carbon tet	8240	GC/MS	0.005		0.001	-	0.01	7.69E+0	
57-74-9	chlordane	8080	GC-ECD	0.009		0.009	-	0.05	7.69E-1	
	chlordane	8080	GC-ECD	0.01		0.0017	-	0.01	n/c	⚐
	chlordane	8080	GC-ECD	0.01		0.0017	-	0.01	n/c	⚐
3165-93-3	chloro-2-m	8270	GC/MS	0.66		0.33	-	0.66	2.17E+0	
95-69-2	chloro-2-m	8270	GC/MS	0.66		0.66	-	1.7	1.72E+0	
59-50-7	chloro-3-m	8040	GC-ECD	1.2					n/c	⚐
59-50-7	chloro-3-m	8040	GC-FID	0.24					n/c	⚐
106-47-8	chloroanil	8270	GC/MS	0.33		0.067	-	0.33		
108-90-7	chloroben	8010	GC-Hall	0.003		0.001	-	0.025		
108-90-7	chloroben	8020	GC-PID	0.002		0.001	-	0.01		
108-90-7	chloroben	8240	GC/MS	0.005		0.001	-	0.01		
124-48-1	chlorodibr	8010	GC-Hall	0.002		0.001	-	0.1	1.19E+1	
75-00-3	chloroetha	8010	GC-Hall	0.005		0.001	-	0.5		
75-00-3	chloroetha	8240	GC/MS	0.01		0.001	-	0.01		
110-75-8	chloroethy	8010	GC-Hall	0.001		0.001	-	0.5	n/c	⚐
110-75-8	chloroethy	8240	GC/MS	0.01		0.001	-	0.01	n/c	⚐

67-66-3	chloroform	8010	GC-Hall	0.0005		0.0005	-	0.05	1.64E+2	
67-66-3	chloroform	8240	GC/MS	0.005		0.001	-	0.01	1.64E+2	
74-87-3	chloromet	8010	GC-Hall	0.0008		0.0008	-	0.5	7.69E+1	
74-87-3	chloromet	8240	GC/MS	0.01		0.001	-	0.01	7.69E+1	
91-58-7	chloronap	8120	GC-Hall	0.63		0.33	-	0.63	n/c	🏳
91-58-7	chloronap	8270	GC/MS	0.66		0.017	-	0.66	n/c	🏳
88-73-3	chloronitro	8270	GC/MS	0.66		0.33	-	0.66	4.00E+1	
100-00-5	chloronitro	8270	GC/MS	0.66		0.33	-	0.66	5.56E+1	
95-57-8	chlorophe	8040	GC-FID	0.21		0.33	-	1.5		
95-57-8	chlorophe	8270	GC/MS	0.66		0.17	-	0.66		
95-57-8	chlorophenol;2-		GC-ECD	0.39		0.067	-	0.39		
7005-72-3	chlorophe	8270	GC/MS	0.66		0.017	-	0.66	n/c	🏳
1897-45-6	chlorthalo	8080	GC-ECD	0.01		0.0083	-	0.01	9.09E+1	
6065-83-1	chromium	3050/7190	FAA	25	☝	0.25	-	1		
6065-83-1	chromium	3050/7191	GFAA	0.5		0.25	-	0.5		
7440-47-3	chromium(VI) (**)								n/c	
218-01-9	chrysene	8270	GC/MS	0.66		0.01	-	0.66	1.37E-1	💣
218-01-9	chrysene	8310	HPLC	0.1		0.01	-	0.1	1.37E-1	
7440-50-8	copper	6010	ICP	3		0.5	-	1		
7440-50-8	copper	7211	GFAA	0.5						
108-39-4	cresol;m-	8270	GC/MS	0.66		0.033	-	0.66		
95-48-7	cresol;o-	8270	GC/MS	0.66		0.033	-	0.66		
106-44-5	cresol;p-	8270	GC/MS	0.66		0.033	-	0.66		
57-12-5	cyanide									
57-12-5	cyanide	M4500-CN	color	5		0.5	-	5		
75-99-0	dalapon, s	8150	GC-ECD	1.2		0.1	-	1.2		
94-82-6	DB;2,4-	8150	GC-ECD	0.18						
72-54-8	DDD;p,p'-	8080	GC-ECD	0.007		0.0017	-	0.007	4.17E+0	
72-55-9	DDE;p,p'-	8080	GC-ECD	0.003		0.0017	-	0.1	2.94E+0	
50-29-3	DDT;p,p'-	8080	GC-ECD	0.008		0.0017	-	0.1	2.94E+0	
84-74-2	di-n-butyl	8060	GC-ECD	0.004						
84-74-2	di-n-butyl	8270	GC/MS	1.7		0.033	-	1.7		
117-84-0	di-n-octyl	8060	GC-ECD	0.03						
117-84-0	di-n-octyl	8270	GC/MS	0.66		0.017	-	0.66		
2303-16-4	diallate	8150	GC-ECD	0.15					1.64E+1	
333-41-5	diazinon	8140	GC-FPD	0.12		0.0017	-	0.033		
53-70-3	dibenz[a,h	8270	GC/MS	0.66		0.01	-	0.66	1.37E-1	💣
53-70-3	dibenz[a,h	8310	HPLC	0.02		0.01	-	0.66	1.37E-1	
132-64-9	dibenzofu	8270	GC/MS	0.33		0.033	-	0.33		
124-48-1	dibromoch	8010	GC-Hall	0.0009		0.0009	-	0.1	1.19E+1	
124-48-1	dibromoch	8240	GC/MS	0.005		0.001	-	0.01	1.19E+1	
124-48-1	dibromoch	8240	GC/MS	0.005		0.001	-	0.01	1.19E+1	
1918-00-9	dicamba	8150	GC-ECD	0.054		0.01	-	0.3		
95-50-1	dichlorobe	8010	GC-Hall	0.0015		0.0015	-	0.1		
95-50-1	dichlorobe	8020	GC-PID	0.004		0.004	-	0.01		
95-50-1	dichlorobe	8120	GC-ECD	0.76		0.01	-	0.76		

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95-50-1	dichlorobe	8270	GC/MS	0.66		0.017	-	0.66		
541-73-1	dichlorobe	8010	GC-Hall	0.0032		0.0032	-	0.33	n/c	⚐
541-73-1	dichlorobe	8020	GC-PID	0.004		0.004	-	0.33	n/c	⚐
541-73-1	dichlorobe	8120	GC-ECD	0.8		0.01	-	0.8	n/c	⚐
541-73-1	dichlorobe	8270	GC/MS	0.66		0.017	-	0.66	n/c	⚐
106-46-7	dichlorobe	8010	GC-Hall	0.0024		0.0024	-	0.33	4.17E+1	
106-46-7	dichlorobe	8020	GC-PID	0.003		0.003	-	0.33	4.17E+1	
106-46-7	dichlorobe	8120	GC-ECD	0.9		0.33	-	0.9	4.17E+1	
106-46-7	dichlorobe	8270	GC/MS	0.66		0.01	-	0.66	4.17E+1	
91-94-1	dichlorobe	8270	GC/MS	1.3		0.033	-	1.3	2.22E+0	
75-71-8	dichlorodi	8010	GC-Hall	0.002		0.001	-	0.02		
75-71-8	dichlorodi	8240	GC/MS	0.005		0.001	-	0.05		
75-34-3	dichloroet	8010	GC-Hall	0.0007		0.0007	-	0.01		
75-34-3	dichloroet	8240	GC/MS	0.005		0.001	-	0.1		
107-06-2	dichloroet	8010	GC-Hall	0.0003		0.0003	-	0.01	1.10E+1	
107-06-2	dichloroet	8240	GC/MS	0.005		0.001	-	0.1	1.10E+1	
156-60-5	dichloroet	8010	GC-Hall	0.001		0.001	-	0.05		
156-60-5	dichloroet	8240	GC/MS	0.005		0.001	-	0.01		
75-35-4	dichloroet	8010	GC-Hall	0.001		0.001	-	0.05	1.67E+0	
75-35-4	dichloroet	8240	GC/MS	0.005		0.001	-	0.01	1.67E+0	
540-59-0	dichloroet	8010	GC-Hall	0.001		0.001	-	0.01	n/c	⚐
540-59-0	dichloroet	8240	GC/MS	0.005		0.001	-	0.01	n/c	⚐
156-59-2	dichloroet	8010	GC-Hall	0.001		0.001	-	0.01		
156-59-2	dichloroet	8240	GC/MS	0.005		0.001	-	0.01		
120-83-2	dichloroph	8040	GC-FID	0.26		0.033	-	0.33		
120-83-2	dichloroph	8270	GC/MS	0.66		0.033	-	1.7		
120-83-2	dichlorophenol;2,4-		GC-ECD	0.46						
94-75-7	dichloroph	8150	GC-ECD	0.24		0.04	-	1		
78-87-5	dichloropr	8010	GC-Hall	0.0004		0.0004	-	0.1	1.47E+1	
78-87-5	dichloropr	8240	GC/MS	0.005		0.001	-	0.01	1.47E+1	
542-75-6	dichloropr	8010	GC-Hall	0.003		0.001	-	0.01	5.56E+0	
542-75-6	dichloropr	8240	GC/MS	0.005		0.001	-	0.01	5.56E+0	
	dichloropr	8010	GC-Hall	0.003		0.001	-	0.2	n/c	⚐
	dichloropr	8240	GC/MS	0.005		0.001	-	0.01	n/c	⚐
	dichloropr	8240	GC/MS	0.005		0.001	-	0.1	n/c	⚐
	dichloropr	8010	GC-Hall	0.003		0.001	-	0.01	n/c	⚐
60-57-1	dieldrin	8080	GC-ECD	0.001		0.001	-	0.01	6.25E-2	
84-66-2	diethyl ph	8060	GC-FID	21						
84-66-2	diethyl ph	8270	GC/MS	0.66		0.033	-	0.66		
84-66-2	diethyl phthalate		GC-ECD	0.33						
119-90-4	dimethoxy	8270	GC/MS	1		0.33	-	1	7.14E+1	
131-11-3	dimethyl p	8060	GC-FID	13						
131-11-3	dimethyl p	8270	GC/MS	0.66		0.01	-	0.66		
131-11-3	dimethyl phthalate		GC-ECD	0.19		0.19	-	0.33		
119-93-7	dimethylb	8270	GC/MS	1		0.33	-	1	1.09E-1	💣
540-73-8	dimethylh	8270	GC/MS	1		1	-	1.7	7.14E-4	💣

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105-67-9	dimethylp	8040	GC-FID	0.21						
105-67-9	dimethylp	8270	GC/MS	0.66		0.033	-	0.66		
105-67-9	dimethylphenol;2,4-		GC-ECD	0.42						
534-52-1	dinitro-o-c	8270	GC/MS	3.3		0.033	-	3.3	n/c	
51-28-5	dinitrophe	8040	GC-FID	8.7		0.067	-	8.7		
51-28-5	dinitrophe	8270	GC/MS	3.3		0.067	-	3.3		
121-14-2	dinitrotolu	8090	GC-ECD	0.013		0.013	-	0.33		
121-14-2	dinitrotolu	8270	GC/MS	0.66		0.013	-	0.66		
606-20-2	dinitrotolu	8090	GC-ECD	0.007		0.007	-	0.66		
606-20-2	dinitrotolu	8270	GC/MS	0.66		0.013	-	0.66		
88-85-1	dinoseb	8150	GC-ECD	0.014		0.0017	-	0.05		
88-85-1	dinoseb	8270	GC/MS							
123-91-1	dioxane;1,	8240	GC/MS	0.01		0.01	-	0.5	9.09E+1	
122-66-7	diphenylh	8270	GC/MS	0.66		0.067	-	0.66	1.25E+0	
298-04-4	disulfoton	8140	GC-FPD	0.13		0.0017	-	0.13		
298-04-4	disulfoton	8270	GC/MS							
	endosulfa	8080	GC-ECD						n/c	
	endosulfa	8080	GC-ECD	0.009		0.0017	-	0.1	n/c	
	endosulfa	8080	GC-ECD	0.003		0.0017	-	0.1	n/c	
1031-07-8	endosulfa	8080	GC-ECD	0.044		0.0017	-	0.1	n/c	
145-73-3	endothall									
72-20-8	endrin	8080	GC-ECD	0.004		0.0017	-	0.1		
3494-70-5	endrin ket	8250	GC/MS						n/c	
106-89-8	epichlorohydrin								1.01E+2	
140-88-5	ethyl acryl	8020	GC-PID	0.1		0.1	-	0.33	2.08E+1	
100-41-4	ethylbenze	8020	GC-PID	0.002		0.001	-	0.04		
100-41-4	ethylbenze	8240	GC/MS	0.005		0.001	-	0.01		
106-93-4	ethylene d	8011	GC/ECD	0.002		0.002	-	0.005	1.18E-2	
107-21-1	ethylene g	8240	GC-FID	10		0.33	-	10		
96-45-7	ethylene th	*632	HPLC						2.78E+1	
206-44-0	fluoranthe	8270	GC/MS	0.66		0.005	-	0.66		
206-44-0	fluoranthe	8310	HPLC	0.14		0.01	-	0.14		
86-73-7	fluorene	8270	GC/MS	0.66		0.005	-	0.66		
86-73-7	fluorene	8300	HPLC	0.14		0.005	-	0.14		
133-07-3	folpet								2.86E+2	
67-45-8	furazolidone								2.63E-1	
531-82-8	furium								2.00E-2	
76-44-8	heptachlo	8080	GC-ECD	0.002		0.0017	-	0.1	2.22E-1	
1024-57-3	heptachlo	8080	GC-ECD	0.056		0.0017	-	0.1	1.10E-1	
118-74-1	hexachlor	8120	GC-ECD	0.034		0.034	-	0.33	6.25E-1	
118-74-1	hexachlor	8270	GC/MS	0.66		0.017	-	0.66	6.25E-1	
87-68-3	hexachlor	8120	GC-ECD	0.23		0.23	-	0.33	1.28E+1	
87-68-3	hexachlor	8270	GC/MS	0.66		0.033	-	0.66	1.28E+1	
319-84-6	hexachlor	8080	GC-ECD	0.002		0.0017	-	0.002	1.59E-1	
319-85-7	hexachlor	8080	GC-ECD	0.004		0.0017	-	0.004	5.56E-1	
319-86-8	hexachlor	8080	GC-ECD	0.006		0.0017	-	0.006		

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58-89-9	hexachlor	8080	GC-ECD	0.003		0.0017	-	0.008	7.69E-1	
58-89-9	hexachlor	8270	GC/MS						7.69E-1	
77-47-4	hexachlor	8120	GC-ECD	0.27		0.27	-	0.33		
77-47-4	hexachlor	8270	GC/MS	0.66		0.033	-	0.66		
67-72-1	hexachlor	8120	GC-ECD	0.02		0.02	-	0.33	7.14E+1	
67-72-1	hexachlor	8270	GC/MS	0.66		0.033	-	0.66	7.14E+1	
591-78-6	hexanone;	8240	GC/MS	0.05		0.001	-	0.05	n/c	
302-01-2	hydrazine	8270	GC/MS	1.3					3.33E-1	
193-39-5	indeno[1,2	8270	GC/MS	0.66		0.01	-	0.66		
193-39-5	indeno[1,2	8310	HPLC	0.029		0.01	-	0.029		
78-59-1	isophoron	8090	GC-FID	3.8		0.33	-	3.8	1.05E+3	
78-59-1	isophoron	8270	GC/MS	0.66		0.033	-	0.66	1.05E+3	
78-59-1	isophorone		GC-ECD	11					1.05E+3	
7439-92-1	lead	6010	ICP	21		1.25	-	8		
7439-92-1	lead	7420	FAA	50		0.125	-	0.5		
7439-92-1	lead	7421	GFAA	0.5		0.125	-	0.5		
121-75-5	malathion	8150	GC-FPD	#VALUE!						
7439-97-6	mercury (i	7470	AA	0.002		0.125	-	0.5		
7439-97-6	mercury (i	7471	AA	0.002		0.1	-	1		
72-43-5	methoxych	8080	GC-ECD	0.12		0.0017	-	0.12		
72-43-5	methoxych	8270	GC/MS							
74-83-9	methyl bro	9011	GC-ECD	0.01		0.001	-	0.01		
78-93-3	methyl eth	8015	GC-FID	0.1		0.001	-	0.05		
78-93-3	methyl eth	8240	GC/MS	0.01		0.001	-	0.05		
108-10-1	methyl iso	8015	GC-FID	0.1		0.001	-	0.05		
108-10-1	methyl iso	8240	GC/MS	0.01		0.001	-	0.05		
298-00-0	methyl par	8140	GC-FPD	0.02		0.005	-	0.02		
94-74-6	methyl-4-c	8150	GC-ECD	50		5	-	50		
636-21-5	methylana	8270	GC/MS	0.66		0.33	-	0.66	5.56E+0	
	methylana	8270	GC/MS	0.66		0.33	-	0.66	n/c	
75-09-2	methylene	8010	GC-Hall			0.001	-	0.01	1.33E+2	
75-09-2	methylene	8240	GC/MS	0.005		0.001	-	0.01	1.33E+2	
	methylnap	8270	GC/MS	0.66		0.017	-	0.66	n/c	
2385-85-5	mirex	8270	GC/MS						5.56E-1	
91-20-3	naphthale	8100	GC-FID	0.66		0.05	-	0.66		
91-20-3	naphthale	8270	GC/MS	0.66		0.005	-	0.66		
91-20-3	naphthale	8310	HPLC	1.2		0.05	-	1.2		
vailable03	nickel, refi	6010	ICP	7.5		1	-	4		
7440-02-0	nickel, sol	7520	FAA	20						
88-74-4	nitroanilin	8270	GC/MS	3.3		0.1	-	33	n/c	
99-09-2	nitroanilin	8270	GC/MS	3.3		0.1	-	33	n/c	
100-01-6	nitroanilin	8270	GC/MS	1.6		0.1	-	33	n/c	
98-95-3	nitrobenze	8090	GC-FID	2.4		1.7	-	2.4		
98-95-3	nitrobenze	8270	GC/MS	0.66		0.033	-	0.66		
98-95-3	nitrobenzene		GC-ECD	9.2		0.33	-	9.2		
59-87-0	nitrofurazone								6.67E-1	

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	nitrophenol	8040	GC-FID	0.3					n/c	
	nitrophenol	8270	GC/MS	0.66					n/c	
	nitrophenol;2-		GC-ECD	0.52		0.033	-	0.52	n/c	
	nitrophenol	8040	GC-FID	1.9					n/c	
	nitrophenol	8270	GC/MS	3.3					n/c	
	nitrophenol;4-		GC-ECD	0.47					n/c	
924-16-3	nitroso-di-	8070	-Hall/GC-N						1.85E-1	
924-16-3	nitroso-di-	8250	GC/MS	1.3		0.33	-	1.3	1.85E-1	
621-64-7	nitroso-di-	8070	-Hall/GC-N						1.43E-1	
621-64-7	nitroso-di-	8250	GC/MS	1.3		0.033	-	1.3	1.43E-1	
1116-54-7	nitrosodie	8070	-Hall/GC-N						3.57E-1	
1116-54-7	nitrosodie	8270	GC/MS	1.3		0.33	-	1.3	3.57E-1	
55-18-5	nitrosodie	8070	-Hall/GC-N						6.67E-3	
55-18-5	nitrosodie	8270	GC/MS	1.3		0.33	-	1.3	6.67E-3	
62-75-9	nitrosodim	8070	-Hall/GC-N	0.002					1.96E-2	
62-75-9	nitrosodim	8270	GC/MS	1.3		0.33	-	1.3	1.96E-2	
86-30-6	nitrosodip	8070	-Hall/GC-N	0.008					2.04E+2	
86-30-6	nitrosodip	8270	GC/MS	0.66		0.033	-	0.66	2.04E+2	
0595-95-6	nitrosome	8070	-Hall/GC-N						4.55E-2	
0595-95-6	nitrosome	8270	GC/MS	1.3		0.33	-	1.3	4.55E-2	
930-55-2	nitrosopyr	8070	-Hall/GC-N						4.76E-1	
930-55-2	nitrosopyr	8270	GC/MS	1.3		0.33	-	1.3	4.76E-1	
56-38-2	parathion	8141	GC	0.06		0.0033	-	0.06		
608-93-5	pentachlo	8270	GC/MS							
87-86-5	pentachlo	8040	GC-FID	5		0.067	-	5	8.33E+0	
87-86-5	pentachlo	8270	GC/MS	3.3					8.33E+0	
87-86-5	pentachlorophenol		GC-ECD	0.4					8.33E+0	
85-01-8	phenanthr	8270	GC/MS	0.66		0.005	-	0.66	n/c	
85-01-8	phenanthr	8310	HPLC	0.43		0.0083	-	0.43	n/c	
108-95-2	phenol	8040	GC-FID	0.094						
108-95-2	phenol	8270	GC/MS	0.66		0.1	-	1.5		
108-95-2	phenol		GC-ECD	1.5						
93-65-2	propionic	8150	GC-ECD	38		5	-	38		
129-00-0	pyrene	8270	GC/MS	0.66		0.005	-	0.66		
129-00-0	pyrene	8310	HPLC	0.18		0.01	-	0.18		
7782-49-2	selenium	6010	ICP	0.75		2.5	-	20		
7782-49-2	selenium	7740	GFAA	5		0.125	-	0.5		
7782-49-2	selenium	7741	GHAA	1						
7440-22-4	silver	6010		3.5						
7440-22-4	silver	7740		5		0.25	-	1		
7440-22-4	silver	7741		0.1		0.05	-	0.25		
122-34-9	simazine	619	GC/NP	0.33		0.033	-	0.33	8.33E+0	
100-42-5	styrene	8240	GC/MS	0.005		0.001	-	0.01	3.33E+1	
1746-01-6	TCDD;2,3,	8290	GC/MS	0.000003					6.67E-6	
	TCDF;2,3,	8290	GC/MS	0.000003					n/c	
95-94-3	tetrachloro	8270	GC/MS	0.33						

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79-34-5	tetrachloro	8010	GC-Hall	0.0003		0.0003	-	0.1	5.00E+0	
79-34-5	tetrachloro	8240	GC/MS	0.005		0.001	-	0.01	5.00E+0	
127-18-4	tetrachloro	8010	GC-Hall	0.0003		0.0003	-	0.05	1.96E+1	
5216-25-1	tetrachlorotoluene;P,a,a,a-								5.00E-2	
961-11-5	tetrachlorv	8141	GC/FPD	0.4		0.005	-	0.4	4.17E+1	
108-88-3	toluene	8020	GC-PID	0.002		0.001	-	0.025		
108-88-3	toluene	8240	GC/MS	0.005		0.001	-	0.01		
95-80-7	toluene-2,4-diamine								3.13E-1	
95-53-4	toluidine;o	8270	GC/MS	0.33					4.17E+0	
8001-35-2	toxaphene	8080	GC-ECD	0.16		0.017	-	1	9.09E-1	
93-72-1	TP;2,4,5- (	8150	GC-ECD	0.034		0.01	-	0.1		
120-82-1	trichlorobe	8120	GC-ECD	0.034		0.034	-	0.33		
120-82-1	trichlorobe	8270	GC/MS	0.66		0.017	-	0.66		
71-55-6	trichloroet	8010	GC-Hall	0.0003		0.0003	-	0.05		
71-55-6	trichloroet	8240	GC/MS	0.005		0.001	-	0.01		
79-00-5	trichloroet	8010	GC-Hall	0.0002		0.0002	-	0.1	1.75E+1	
79-00-5	trichloroet	8240	GC/MS	0.005		0.001	-	0.01	1.75E+1	
79-01-6	trichloroet	8010	GC-Hall	0.001		0.001	-	0.01	9.09E+1	
75-69-4	trichloroflu	8010	GC-Hall	0.002		0.001	-	0.025		
75-69-4	trichloroflu	8240	GC/MS	0.005		0.001	-	0.01		
95-95-4	trichloroph	8270	GC/MS	0.66		0.033	-	1.7		
88-06-2	trichloroph	8040	GC-FID	0.43		0.033	-	1.7	9.09E+1	
88-06-2	trichloroph	8270	GC/MS	0.66					9.09E+1	
88-06-2	trichlorophenol;2,4,6		GC-ECD	0.39					9.09E+1	
93-76-5	trichloroph	8150	GC-ECD	0.04		0.01	-	0.2		
512-56-1	trimethyl p	8270	GC/MS						2.70E+1	
108-05-4	vinyl aceta	8240	GC/MS	0.05		0.001	-	0.05		
75-01-4	vinyl chlor	8010	GC-Hall	0.002			1		5.26E-1	
75-01-4	vinyl chlor	8240	GC/MS	0.02		0.001	-	0.01	5.26E-1	
1330-20-7	xylene (tot	8020	GC-PID	0.002		0.001	-	0.04		
1330-20-7	xylene (tot	8240	GC/MS	0.005		0.001	-	0.01		
108-38-3	xylene;m-	8020	GC-PID	0.002		0.001	-	0.01		
108-38-3	xylene;m-	8240	GC/MS	0.005		0.001	-	0.01		
95-47-6	xylene;o-	8020	GC-PID	0.002		0.001	-	0.01		
95-47-6	xylene;o-	8240	GC/MS	0.005		0.001	-	0.01		
106-42-3	xylene;p-	8020	GC-PID	0.002		0.001	-	0.01	n/c	
106-42-3	xylene;p-	8240	GC/MS	0.005		0.001	-	0.01	n/c	
7440-66-6	zinc	6010	ICP	1		0.5	-	2		
7440-66-6	zinc	7951	AA	0.03						

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Kenny, Ann

From:	Kmet, Peter
Sent:	Monday, September 11, 2000 11:51 AM
To:	Fitzpatrick, Kevin
Subject:	RE: Clean Fill Criteria Language for the 401 Water Quality Certification on the Sea Tac Third Runway

Here are my comments. Make sure you open the attachment.

Clean Fill Criteria for 401 Ce...

-----Original Message-----
From: Fitzpatrick, Kevin
Sent: Friday, September 08, 2000 12:52 PM
To: Kmet, Peter
Subject: Clean Fill Criteria Language for the 401 Water Quality Certification on the Sea Tac Third Runway

DELIBERATIVE DOCUMENT CURRENTLY EXEMPT FROM PUBLIC DISCLOSURE

Pete: The following are additions that have been made to the 401 Certification language which are not reflected in the attached Word document below.

E6. It sounds like we are allowing the Port to use problem fill as long as the Port notify Ecology. I think the second sentence should exclude the use of inappropriate fill that may result in any potential impacts to waters of the state.

E7c.2.(b) Should include appropriate EPA databases and the first list should read as "Confirmed & Suspected Contaminated Sites Report"

E7c.2.(e) "The fill material shall be analyzed for the potential contaminant(s) identified in the environmental site assessment. At a minimum, fill material from all sites shall be analyzed for TPH and Priority Pollutants metals for compliance with MTCA method A soil cleanup levels in WAC 173-340-740." In the absence of MTCA method A soil cleanup levels, the potential contaminants shall comply with MTCA method B ~~"100 X Groundwater"~~ soil cleanup levels." [There is more to Method B than the 100 X standard. Also, we are in the process of changing that to another model and so this is no longer valid.] The sampling frequency . .

[NOTE: there are two method A cleanup tables, unrestricted and industrial soils. I'm assuming you mean unrestricted soil cleanup levels, which is why I added the reference. However, there is a problem with this language in that Method A does not have standards for all contaminants AND they are in the process of being changed. I wonder if you should instead cite natural background as the standard.]

[The reference to Method B makes no sense because Method B does not specify specific substances to analyze for. If I had to say anything here, I would say "contaminants with the potential to be in the fill material based on historical site use, available records and previous test data. For these contaminants the standard would have to be based on Method B soil cleanup levels in WAC 173-340-740. Again, there is a bit of a problem because the standards are changing.]

See if you want to add E7c.2.(f) after the sampling requirement table. This is a repeat of a sort

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since the term "environmental professional" is already used in couple of places.

(f) All work shall be performed by an environmental professional, with appropriate training, experience and expertise in environmental site assessment.

E7c.3. I don't think they know where the placement location yet. The location should be included in the as-builts to be submitted quarterly.

<< File: Clean Fill Criteria for 401 Certification.doc >>

Kevin C. Fitzpatrick
Supervisor, Industrial Permit Unit
Water Quality Program, NWRO
Voice: 425-649-7037
Fax: 425-649-7098
KFIT461@ecy.wa.gov

E6. Borrow sites:

The use of fill from Port of Seattle borrow sites or other sources may result in impacts to wetlands or other waters of the state requiring additional review and approval by Ecology. The Port shall notify Ecology when the use of borrow sites on their property or from other sources may result in any potential impacts to waters of the state.

E7. Clean Fill Criteria, Certification, and Monitoring: The Port shall ensure that fill placed for the proposed project does not contain toxic materials in toxic amounts. The Port of Seattle is prohibited from using any soils or fill materials on this project that are contaminated as defined under Washington State's Model Toxics Control Act (MTCA) or any soils or fill materials which are being removed or have been treated as part of a site cleanup under MTCA, federal superfund, water quality or local health district laws. ~~were contaminated and then remediated to MTCA cleanup standards.~~ The Port shall adhere to the following conditions for fill used for this project:

E7a. Fill material shall be derived from the following sources only:

- State-certified native soil borrow pits
- Contractor-certified construction sites
- ~~Port-owned property~~

[I see no reason for distinguishing port property from any other. What does "state certified" mean? Certified by who for what purpose?]

E7b. Documentation: For materials derived from the three sources listed above, the Port and/or its contractors shall provide documentation to Ecology that a source has been certified to contain materials that are considered as clean fill. This documentation shall provide sufficient information to Ecology to evaluate whether or not the fill sources contain toxic materials in toxic amounts.

This documentation of a source's clean fill certification shall at a minimum contain the information described in E7c and shall be provided to Ecology's Water Quality Program at its Northwest Regional Office in Bellevue, WA no later than two business days prior to the acceptance of any of the source materials at a Sea-Tac International Airport construction site.

E7c. The information requirements on a source's certification shall contain at a minimum the following elements:

1. Site description with the site name and address, site plan indicating the extent of excavation, project schedule and estimated quantity of fill to be removed from the site.

2. Site investigation report which will contain at a minimum the following:

(a) Observation of the source area and adjacent areas by an environmental professional which includes reports of any known probability of environmental impact from historical use on site or on adjacent areas.

(b) Due diligence review of whether the source locations or adjacent areas are listed on the most current editions of the following Ecology databases:

(1). The ~~confirmed of~~ Confirmed and suspected Contaminated Sites list;
(2). The Underground Storage Tank listings;
(3). The Leaking Underground Storage Tank listings.

There is at least one other list of suspected sites maintained by EPA, the name of which escapes me.

(c) Due diligence review of source area geologic conditions and use or operational history of the site and adjacent areas sufficient to identify potential environmental contaminants.

(d) If no existing documentation exists for review on the site's history, then a review of site aerial photos, person or persons familiar with the site and adjacent areas and other due diligence methods will be employed to provide a site history.

(e) At a minimum. fill material from all sites shall be analyzed for TPH and priority pollutant metals and compared with MTCA Method A cleanup standards in WAC 173-340-740. [NOTE: there are two method A cleanup tables, unrestricted and industrial soils. I'm assuming you mean unrestricted soil cleanup levels, which is why I added the reference. However, there is a problem with this language in that Method A does not have standards for all contaminants AND they are in the process of being changed.]

Based on the site investigation and review of its operational history, an environmental professional will determine whether any additional analyses are appropriate, including but not limited to, analyses by MTCA Method B cleanup standards. [The reference to Method B makes no sense because Method B does not specify specific substances to analyze for. If I had to say anything here, I would say "contaminants with the potential to be in the fill material based on historical site use, available records and previous test data. For these contaminants the standard would have to be based on Method B soil cleanup levels in WAC 173-340-740. Again, there is a bit of a problem because the standards are changing.]

The sampling frequency for sites where the investigation indicates no suspected contamination will be in accordance with Table 1. Sites with suspected contamination or with complex conditions will require consultation with the Department of Ecology, Water Quality Program, NWRO to determine the appropriate sampling frequency.

This sampling frequency is insufficient to determine compliance with the MTCA standards. To comply with the standards, a site must meet three requirements:

1. Upper 95% confidence limit on test results must meet standard.
2. No more than 10% of the samples can be above the standard.
3. No one sample can be more than twice the standard.

This first test requires statistical analyses. Typically, you need at least 10 samples to get the confidence limit narrow enough to pass. So, your proposed sampling schedule is not sufficient. Also, your sampling schedule is not likely to find contamination. I think the biggest problem is construction sites, not borrow pits. So the below comments reflect this.

I suggest you go with something more like the one in our petroleum contaminated soil guidance for construction sites and port owned property. This acknowleges:

VOLUME OF SOIL (cubic yards)	MINIMUM NUMBER OF SAMPLES
0-100	3
101-500	5
501-1000	7
1001-2000	10
>2000	10 plus 1 for each additional 500 cy.

For native soil borrow pits (which should be clean and also much bigger) I recommend you start with a minimum of 10 samples and go up from there, something like this:

VOLUME OF SOIL (cubic yards)	MINIMUM NUMBER OF SAMPLES
<50,000	10
50,001 – 500,000	15

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>500,000	15 plus 1 for each additional 100,000 CY

VOLUME OF SOIL (cubic yards)	MINIMUM NUMBER OF SAMPLES
<1,000	2
1,000 – 10,000	3
10,000 – 50,000	4
50,000 – 100,000	5
>100,000	6

3. Every source certification will list the initial placement of fill location and its grade elevation. The Port of Seattle will also provide quarterly summaries of each certified source of fill which lists the certified sources employed in that quarter, quantities of fill material from those sources, and the locations and elevation grades for the placement of those fill sources on Port of Seattle property.

Additional conditions or corrective actions may be required based on Ecology's review of the documentation.

E7d. Any changes to the criteria or process described in the above conditions is subject to review and written approval by Ecology.