12 September 2008

Mr. Matt McClincy
Oregon Department of Environmental Quality
Northwest Region
2020 Southwest 4th Avenue, Suite 400
Portland, Oregon 97201-4987

Subject: Former Arkema Portland Plant
Responses to ODEQ/USEPA Comments on the Draft Focused Feasibility Study
Groundwater Source Control Interim Remedial Measure
ECSI No. 398

Dear Matt,

This document provides responses to comments received from the Oregon Department of Environmental Quality (DEQ) and United States Environmental Protection Agency (USEPA) on 29 July 2008 related to the May 2008 *Draft Focused Feasibility Study, Groundwater Source Control Interim Remedial Measure, Arkema Chemicals Facility Portland, Oregon* (FFS). The FFS was prepared by ERM-West, Inc. (ERM) on behalf of Legacy Site Services LLC (LSS), agent for Arkema Inc. Each of the DEQ/USEPA comments is provided below in italic font, followed by LSS's response. LSS does not intend to submit a revised FFS, but rather provides these responses to comments as an addendum to the FFS.

General Comments

1. *The final FFS and subsequent engineering documents must be stamped by an Oregon Professional Engineer.*

   Comment noted.

2. *What is the setback distance from the top of the bank that the various wall options (i.e., sheet pile, slurry or vibrating beam) can be constructed? The document provides a range of values, but there is no clear summary as to how close to the top of the bank the various wall options can be constructed.*

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how close to the top of the bank the various wall options can be constructed. Ideally walls considered for the top of bank location would be as close to the top of bank as possible as this will contain as much contaminant mass as possible. While some of the barrier wall construction option distances may be used in narrow areas on level ground, they may not be acceptable near a slope leading to a river. As presented in the different areas of text, it seems that there will need to be a minimum of 60 to 100 feet from top of bank to the actual barrier wall location. The updated document needs to provide a simple table which covers route clearance, minimum equipment clearance for driving/turning/ installing, and minimum slope failure due to vibration or loading by equipment. The minimum set back requirements need to be highlighted.

LSS agrees that in order to maximize the contained area, the barrier wall should be positioned as close to the top of river bank (TOB) as possible, taking into consideration slope stability of the bank, construction loads, and equipment/pad construction requirements. A summary of required setbacks from the TOB for the various barrier wall options and clearance trench are summarized in Table H-1 attached to this response to comments. Details regarding the calculation of these distances are provided in Appendix B of the FFS.

As shown on the table, the required setback due to loading from construction equipment during installation is the determining factor for all three barrier wall technologies. The greater setback requirement for the slurry trench barrier wall is due to the fact that the slurry trench is installed directly beneath the installation equipment. By comparison, the equipment used to install a vibrated beam slurry wall or a sheet pile wall can be offset from the wall location. This allows closer installation to the TOB, while maintaining the required distance of the equipment from the TOB.

A clearance trench will be required prior to barrier wall installation to locate and, if necessary, remove/abandon oversize objects, underground utilities (some utilities may need to be temporarily relocated), and/or monitoring wells that would otherwise be obstructions to construction of the barrier wall. A shallower trench will be required for the slurry trench technique than the vibrated beam or sheet pile wall techniques. This is due to the fact that small- to moderate-sized debris can be removed from the deeper fill using

the slurry trenching equipment. A clearance trench for a slurry trench wall would only be required to remove large-sized debris, and cap/remove utilities that cannot be done so remotely. By comparison, the vibrated beam and sheet pile wall techniques require that all debris be removed prior to wall installation.

The setback requirement for the clearance trench of 60 feet, as stated in the FFS, was based on a 2H:1V slope and a 10-feet distance between the edge of the trench and the TOB. The 2H:1V slope was conservatively assumed based on a person entering the trench. Additional analysis of the issue has determined that the clearance trench could be completed, and obstacles removed/abandoned, without entrance into the trench. This would allow a steeper slope (e.g., 0.5H:1V) to be used, thus reducing the required setback. Table H-1 reflects this smaller setback (25 feet). In addition, other methods could be used to shore the trench if a steeper slope is required (e.g., trench box). Details regarding design of the clearance trench, if required, will be specified during design of the Source Control IRM.

Again, it should be noted that for the sheet pile and vibrated beam technologies, the clearance trench drives the required setback, whereas for the slurry trench technology, which requires a smaller clearance trench, the slurry trench equipment loading drives the required setback. As a result, the wall location will likely be between 25 and 30 feet from the TOB. This distance will be further refined as part of the final design.

3. *The requirement for a 25-foot deep pilot trench identified in the conceptual barrier wall details (Figure 4-3) should be explained. This unusually deep trench appears to have a large impact on the setback given the suggested 2:1 slopes and 10-foot setback from the top of bank. The depth is apparently driven by the possibility of large obstructions being encountered throughout the fill. However, the basis for this depth is not clearly explained. A shallower and narrower trench would reduce the required setback and limit excavation of potentially contaminated material.*

As discussed throughout the FFS (e.g., Sections 3.4 and 4.5.1.2) the purpose of the clearance trench is to locate and, if necessary, remove/abandon oversize objects, underground utilities (some

utilities may need to be temporarily relocated), and/or monitoring wells that would otherwise be obstructions to construction of the barrier wall. Because it is possible that debris is present throughout the total depth of fill, the clearance trench for a vibrated beam or sheet pile barrier wall must extend through the entire fill profile (a clearance trench for a slurry trench wall would likely be completed to a shallower depth). The depth of fill is approximately 25 feet along the barrier wall route (see Figure 4-2 from the Remedial Investigation [RI] report).

As discussed in the response to Comment 3 above, it is believed a steeper clearance trench slope (e.g., 0.5H:1V) could be employed in order to reduce the required setback (and reduce the amount of excavation required). In addition, other methods could be used to shore the trench if a steeper slope is required (e.g., trench box). Details regarding design of the clearance trench, if necessary, will be specified during design of the Source Control IRM.

4. *Management options for the soil excavated from the pilot trench are not identified. Off-site disposal of soil exceeding preliminary hot spot values should be assumed.*

   LSS assumes the agencies are referring to the clearance trench in this comment. Soil excavated from the clearance trench will be placed back in the excavation following removal of large debris and abandonment/relocation of utilities as required. Appropriate measures will be implemented to prevent any potential contaminant migration from the temporarily stockpiled soils (e.g., plastic sheeting placed under stock piles, erosion control, etc.). Off-site disposal of a portion of the trench spoils was conservatively assumed in the cost evaluation to address any soils encountered that would be unsuitable for placement back into the clearance trench.

5. *If the deep pilot trench will extend below the groundwater table, the FFS should discuss implications for slope stability and groundwater management.*

   LSS assumes the agencies are referring to the clearance trench. It is expected that the clearance trench will extend to approximately 25

feet below ground surface (bgs). Along the barrier wall route, shallow groundwater is generally encountered at 20 to 25 feet bgs. As such, the excavation into the saturated zone is expected to be minimal. To the extent required, typical construction dewatering pumps may be used during excavation of the trench. It is expected that any pumped water will be stored on site for eventual treatment, as necessary, and discharge to the Willamette River. Additional details of this, if necessary, would be part of the design of the selected barrier wall option.

6. *The trade-off between the wall footprint location and the total mass, volumes, and concentrations of contaminants which are left outside the wall (the river side of the wall) should be explained in more detail. The wall location should be based on construction needs and optimizing what contamination is being contained and what may be left outside the wall where it is hard to access or contain after the wall is built. As presented, it appears the selected wall location is mostly a matter of ease of construction.*

   LSS agrees that the wall location should be based on construction needs and optimizing what contamination is being contained. As stated in the response to Comment 2, the location of the wall has been selected in order to maximize the contained portion of the site, taking into consideration technically practicable limitations on the installation and effectiveness of the resulting barrier wall.

   As discussed in the FFS, installation of the barrier wall at the toe of the slope is not technically practicable, as it does not provide an effective barrier due to potential "over-topping" of water from the river. Therefore, a barrier wall at the TOB is required. In order to maximize the area of the site which is contained, the barrier wall will be positioned as close to the TOB as possible, taking into consideration slope stability of the bank, construction loads, and equipment/pad construction requirements.

7. *Provide additional figures that show, to-scale both in plan and cross-section, proposed wall locations considered in the FFS, actual spacing needs for clearance work and equipment, stratigraphy including fill, bank slope, river bathymetry and the distribution of contaminants (DDX, DNAPL and any other contaminants that may present a recontamination potential for sediment) outside of the wall.*

Attached Figures H-1 through H-12 (Attachment A) present the proposal barrier wall location overlain with the most recent groundwater concentrations for the primary constituents of concern. The barrier wall route shown on the figures has been surveyed and is based on required bank setback, access, slope, and other site features. The setback from the TOB varies depending up on the steepness of the bank and the other features listed above.

8. *Confirm that the FFS wall options do not preclude future riverbank removal or remedial measures.*

   As discussed in more detail in the response to Comment 9 below, the FFS wall options do not preclude future riverbank removal or other remedial measures. However, LSS points out that the Groundwater Source Control IRM approach of installing a barrier wall and groundwater extraction and treatment system has been prescribed by USEPA. If the USEPA no longer believes in their prescribed IRM, or believes that the IRM will not be compatible with future remedial actions, LSS requests immediate clarification and guidance.

9. *Identify potential upland remedial technologies that will be evaluated in the upland FS to remove or treat source area contaminants and qualitatively evaluate their compatibility with the FS wall options (type and location).*

   The attached Table H-2 summarizes compatibility of each of the barrier wall technologies with a reasonable range of potential future remedial actions for the area of the barrier wall. As shown in the table, the barrier wall technologies are all generally expected to be compatible with possible future remedial actions, with the possible exception of a sheet pile wall with several of the technologies.

   The wall location (i.e., full enclosure or river side high bank) does not affect compatibility with future remedial actions and therefore is not addressed in Table H-2.

10. *The FFS should include a qualitative comparison of the wall options resistance to a seismic event and ease of repair should it be damaged.*

A slurry trench barrier wall would be resistant to minor seismic dynamic loads, and might survive a moderate seismic event with little damage due to the relatively low strength and relatively thick soil-slurry backfill used to construct a slurry trench wall. Any damage from such an event could likely be repaired by targeted slurry injections to repair the areas where it has been determined leaking is occurring.

A vibrated beam barrier wall would be resistant to minor seismic dynamic loads, and might survive a moderate seismic event with little damage, although less so than a slurry trench wall due to the somewhat greater strength and thinner width used to construct a vibrated beam wall. Any damage from such an event could likely be repaired by targeted slurry injections to repair the areas where it has been determined leaking is occurring.

A sheet pile GWBW would be very resistant to minor seismic dynamic loads, and might survive a moderate seismic event with little damage, even more than a slurry trench barrier wall or vibrated beam barrier wall due to the much greater strength and ductility of the steel sheets used to construct a sheet pile barrier wall. If leaks at joints or at the bottom of the wall occurred due to shifting of panels during a significant seismic event, these issues could be resolved by either re-driving the piles into place, or, if damage has occurred to the piles or joints, through replacement of the affected sheet piles.

A seismic event of sufficient magnitude might cause slippage along the face of, or through, the groundwater barrier wall, causing failure of the river bank slope. Repair of the wall following such an event would require backfilling of the impacted area and reinstallation of the barrier wall through the affected section.

11. *QA/QC requirements for the barrier wall options are critical for assurance of proper barrier construction in accordance with the design. Each of the alternatives is likely to require different QA/QC measures. The QA/QC requirements should be described for each option and the documented historical ability of these measures to assure quality should be considered in the alternative evaluation.*

All three technologies would require similar scope of CQA/CQC inspection and testing, and the CQA/CQC inspection and testing would provide similar measures of quality of the constructed barrier wall. Therefore, CQA/CQC requirements and effectiveness do not impact barrier wall technology selection. A revised Table 5-1 that reflects CQA/CQC inspection and testing is attached to this response to comments. General CQA/CQC procedures for each technology evaluated are presented below.

The required construction quality assurance (CQA) and construction quality control (CQC) for a **vibrated beam slurry wall** are as follows:

The quality of the construction would be measured by inspection and testing prior to and during construction of the barrier wall. Pre-construction CQA/CQC inspection and testing would include:

- Inspection of the clay-cement additive manufacturer's specifications;
- Staking the barrier wall route;
- Inspection of the work platform, slurry containment, and slurry reservoir trench; and
- Inspection of the slurry mix and excavation equipment for suitability for use to accomplish the work.

CQA/CQA inspection and testing during construction would include:

- Field testing of samples of the slurry for unit weight and viscosity;
- Measurement of the vibrated beam leads for state of plumb and adequate prior-panel overlap distance prior to initiating insertion of the vibrated beam into the ground for each panel;
- Measurement of slurry pressure and volume during placement of the vibrated beam;
- Measurement of the maximum depth to which the vibrated beam is inserted below the ground surface at the location of each panel; and
- Placement of a suitable cap at the surface over the completed barrier wall.

The required CQA/CQC for a **slurry trench slurry wall** are as follows:

The quality of the construction would be measured by inspection and testing prior to and during construction of the barrier wall. Pre-construction CQA/CQC inspection and testing would include:

- Inspection of the clay additive manufacturer's specifications;
- Staking the barrier wall route;
- Inspection of the excavation work platform, the slurry mix platform, and the slurry and slurry backfill containment; and
- Inspection of the slurry mix, excavation, and slurry backfill mixing equipment for suitability for use to accomplish the work.

CQA/CQA inspection and testing during construction would include:

- Field testing of samples of the slurry for unit weight and viscosity;
- Measurement of the excavator arm for state of plumb;
- Measurement of the depth and slope of the excavated trench, the slurry backfill in the trench, and the full-trench-depth clearance beyond the toe of the slurry backfill;
- Observation of excavated material for unacceptable material;
- Observation of slurry mixing;
- Sampling and field testing of samples of slurry backfill for slump and unit weight prior to placement in the slurry trench;
- Observation of adequate slurry backfill placement;
- Collection of samples of slurry backfill during placement for laboratory hydraulic conductivity testing; and
- Placement of a suitable cap at the surface over the completed barrier wall.

The required CQA/CQC for a **sealed sheet pile barrier wall** are as follows:

The quality of the construction would be measured by inspection and testing prior to and during construction of the barrier wall. Pre-construction CQA/CQC inspection and testing would include:

- Inspection of the sheet pile and sealant manufacturers' respective materials specifications;
- Staking the barrier wall route;
- Inspection of the work platform, spill containment, and sheet guides and related anchors; and
- Inspection of the sheet pile driving equipment and the sealant mix and injection equipment for suitability for use to accomplish the work.

CQA/CQA inspection and testing during construction would include:

- Inspection of each sheet joint, including welds joining sheets, if necessary;
- Measurement of each sheet pile for state of plumb, proper joint engagement, and proper alignment prior to driving the sheet into the ground;
- Measurement of the rate of sheet advance and total depth, including staged driving, during placement of each sheet; and
- Placement of a suitable cap at the surface over the completed barrier wall.

12. *The FFS should document any discussions or issues communicated by the natural resource agencies in regards to wall alignment potentially encroaching into areas which may be desired for habitat restoration and show any expected setback or other requirements.*

    LSS has not received any communication from these agencies regarding the proposed wall alignment.

General Comments (Future Expectations)

EPA provided the following comments that relate to future project expectations. It is requested that LSS acknowledge them and identify any concerns.

1. *The FFS should indicate that the barrier wall and pumping system is an interim measure, as not to give the impression that the containment system is the final sole remedial action.*

   The remedial action described in the FFS is termed an "Interim Remedial Measure" throughout the document, including the document title. Therefore, the document is clear that the remedy proposed is an interim measure.

2. *The FFS should identify the anticipated longevity of the wall/containment system. For example, does LSS expect that it will be part of the final long-term site remedy? The useful life expectancy of each type of wall and extraction / treatment system combination should be identified as well as a qualitative evaluation of the systems anticipated performance under steady state conditions and extreme conditions such as floods or a seismic event.*

   LSS expects the barrier wall and groundwater extraction and treatment system to be an integral part of the long term, upland remedy at the site. As stated in Section 1.1 of the FFS, it is LSS's intention to implement a remedy that will complement and be compatible with the potential final upland remedy for the Site.

   Regarding useful life expectancy, the materials used to construct a slurry trench or vibrated beam slurry wall are biologically, chemically and mechanically (for non-seismic conditions) stable. Therefore, in the absence of a catastrophic seismic event, the useful life of these types of barrier walls is expected to be indefinite, and certainly in excess of 50 years.

   The materials used to construct a steel sheet pile barrier wall may be subject to slow corrosion. Nonetheless, due to the very low rate of corrosion expected, the useful life of a steel sheet pile barrier wall is expected to be in excess of 50 years.

   Potential flooding impacts to the wall could include overtopping and slope failure resulting from a raised water level followed by relatively rapid dewatering. Overtopping is not expected to occur unless a portion of the wall within the unsaturated zone has been

removed as part of soil excavation. The amount of overtopping would depend upon the amount of wall removed and the flood level reached; therefore the effects on the hydraulic containment system are difficult to quantify. The effects of rapid dewatering on slope failure were evaluated as part of the slope stability analysis in Appendix B of the FFS (rapid drawdown analysis).

Potential seismic impacts are discussed in the response to Comment 10 above.

3. *It is requested that LSS commit to maintenance and repairs of the wall system should it be damaged (e.g., seismic event).*

   LSS intends to perform maintenance and repairs, as necessary and practicable.

4. *The need to have commitments regarding setting performance standards and conducting performance monitoring as part of any option selected, such as inward gradient criteria to maintain water and contaminants in the uplands (with monitoring well locations specified) should be included in the final report. That would affect the selection of the open barrier wall versus the fully enclosed barrier system since the control of an open wall is more difficult than the enclosed one.*

   The comment is unclear. As described in the FFS, performance monitoring following installation of the barrier wall and hydraulic control system will include verification of an inward hydraulic gradient by monitoring water levels at a network of monitoring wells and/or piezometers both inside and outside the barrier wall. Such monitoring will be performed regardless of wall type or location, and therefore does not impact technology or route selection.

   Although hydraulic containment using an "open" barrier wall would require extraction of a larger groundwater flow rate than that required by a fully-enclosed barrier wall, groundwater modeling confirms that containment can be achieved using either configuration.

5. *Much of the design in the draft FFS is based on the modeling done for this project. This may be acceptable (assuming previous EPA comments given on the modeling were incorporated), but the final performance criteria for the barrier wall and pumping system must be based on actual documented monitoring well data, and documented by gradient controls, as described in EPA's Capture Zone Analysis methods.*

   See response to Comment 4 above.

6. *A sufficient number of properly placed monitoring wells should be included in the final design to allow the actual functional system to be evaluated using water levels and other techniques as described in EPA/600/R-08/003, January 2008, A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems.*

   Comment noted. See response to Comment 4 above.

7. *EPA notes that the compatibility of the selected interim remedial measure with future in-water or riverbank remedial work is uncertain and that changes to the constructed interim action may be required.*

   Compatibility of the barrier wall technologies with a reasonable range of potential future remedial actions is addressed in the response to Comment 9 above and the attached Table H-2.

   LSS does not understand the comment that "changes to the constructed interim action may be required" as LSS does not believe that the barrier wall will impede or restrict future upland or in water remedial actions. The barrier wall has been prescribed to LSS by USEPA. If USEPA is now uncertain about its prescribed IRM, LSS requests immediate clarification and guidance.

8. *Should a slurry wall be selected, the implementation work plan should have contingencies to respond to a slurry release to river should wall or piping failures occur.*

   Comment noted.

9. *Design documents should identify the location of all discharge pipes, utilities, or other obstructions at the site along the footprint of the proposed*

barrier wall. Any such obstructions must be documented and removed prior to construction of the wall.

During design of the Groundwater Source Control IRM, drawings will be produced that depict known pipes and utilities along the proposed barrier wall alignment. However, as discussed above, debris and other obstructions are likely to be present within the fill, especially in the area river-side of the Acid Plant. The purpose of the clearance trench will be to identify and remove these obstructions.

Specific Comments

1. *Page 28, Section 3.6 Groundwater Treatability Study - The groundwater treatment effectiveness for removal of metals besides iron should be discussed.*

   Iron was the predominant metal present in the groundwater samples collected for conducting the treatability study, and was detected at dissolved concentrations up to 110 milligrams per liter. Other metals including; arsenic, cadmium, chromium, copper, lead, nickel, selenium, silver, and zinc, were either not detected or detected at trace concentrations. Based on these analytical results, removal of these other metals could not be evaluated as part of the treatability study as they do not occur at elevated levels.

2. *Page 31, Section 4.2 Remedial Action Objectives, Third Bullet – Clarify that while the upland source control measures will proceed on an independent schedule from the non-time-critical in-water removal action, the schedule for source control measures needs to support the in-water action by preceding it and demonstrating the effectiveness of the measures.*

   The schedule states this.

3. *Page 32, Section 4.3 General Response Actions - Sequencing the construction of containment system is important to minimize exacerbation of existing contaminant plumes. The FFS states that hydraulic containment for the River Side High Bank Barrier will require pumping 17-20 extraction wells at a combined rate of approximately 150 gpm. Thus, installation of the wall, in the absence of extraction wells, would result in approximately 1.5 million gallons of contaminated groundwater being diverted around the walls each week and potentially spreading contamination to other areas,*

both onsite and offsite. DEQ recommends that the network of extraction wells be installed prior to construction of the wall (Note the project schedule shows the opposite).

LSS believes that the impacts from groundwater diversion over the short period of time during which the wall would be present without groundwater extraction does not justify the significant schedule delays that would result from the proposed sequencing. It is LSS's desire to compress the construction schedule, rather than to elongate.

4. *Page 34, Section 4.4.1 Groundwater Barrier Wall Technologies – The barrier wall should not preclude subsequent riverbank removal/remedial measures. This topic is listed as the first bullet in this section, but it is not clear how it is addressed.*

   Compatibility of the barrier wall technologies with a reasonable range of potential future remedial actions is addressed in the responses to Comment 9 and 7 (above) and the attached Table H-2.

5. *Report Section 4.4.1.2 and 4.5.1.2, Tables 4-2, 4-6 and 5.1, Barrier Wall Construction Technology, Vibrated Beam Slurry Wall: The government team has concerns about this technology for this application. Eighty-five feet may be beyond an acceptable depth for vibratory beam techniques; anything deeper than 70 feet has increased risks. Keying into the basalt will be difficult. The main problem with the vibratory beam method for this project is potential liquefaction causing damage to an adjacent completed panel. As documented by the USACE and other agencies, this technology can have low reliability in certain conditions, not always achieve the specified thickness, lack continuity between panels, and it is not possible to confirm proper installation using proven QA/QC measures. This documentation consists of internal USACE and Bureau of Reclamation memoranda and is not formally published. Although dated, the documentation supports the concern that the proposed wall technology may not be suitable due to the required depth of installation.*

   LSS notes that the internal memoranda provided with the comments are extremely dated (30 and 25 years old). Furthermore, the portions of the United States Army Corps of Engineers (USACE) and Bureau of Reclamation (BOR) memoranda provided with USEPA comments largely address problems at sites that are dissimilar to the Arkema site, use materials not proposed for use to construct a vibrated beam

barrier wall at the Arkema site, or address prior vibrated beam technology not proposed for construction of a vibrated beam barrier wall. It is not clear from the comment what specific concerns USEPA has regarding the technology.

Use of the vibrated beam technology to construct a barrier wall has been reported to have been successful at many other sites with similar soils, constituents, and ground water gradients. LSS notes that the vibrated beam slurry wall technology has been used for over 30 years to construct ground water barrier walls, including walls deeper than 100 feet below ground surface at other sites. A list of prior vibrated beam projects completed by Slurry Systems, Inc., a leading vibrated beam contractor, including the project location, approximate cost, slurry type, length, depth, total vertical square footage, and project references is attached to these responses (Attachment B). This table shows approximately 70 vibrated beam slurry walls that have been installed over the past 30+ years by Slurry Systems alone, and that the vibrated beam technology has been demonstrated to be capable of being constructed to the maximum design depth of 87 feet bgs.

Keying into the basalt is not needed nor proposed. Therefore, the ability to key into basalt is not a criterion for evaluation of the barrier wall technology.

Liquefaction of the material placed in the adjacent panel has not been reported to be a problem that has adversely affected the performance of a barrier wall constructed using the vibrated beam technology.

The specified thickness of the vibrated beam slurry wall is controlled by the injection tool at the base of the vibrated beam. The injected slurry serves to support the opening. The act of injection causes mixing of soil fines, including sand- and silt-sized particles, into the slurry, and some slurry infiltrates the pore space in the adjacent unmixed formation. Therefore, the width of the slurry-cemented wall will actually be greater than the 4-inch width of the slurry injection tool, thereby providing a factor of safety on the width of the barrier wall.

The vibrated beam tool has a 14-inch long fin that serves as a guide during travel of the vibrated beam to the total depth. The end of the vibrated beam is lapped approximately three inches over the previously placed panel, and the fin extends an additional 14 inches into the previously placed panel. As a result, the beam and fin overlap the previous panel by 17 inches. As the beam and injection tool are approximately 33 inches wide, the bean and fin effectively overlap over 50 percent of the width of the previous panel. Because the previous panel is much weaker than the surrounding undisturbed formation, the fin and the vibrated beam are effectively guided by the relatively stronger, undisturbed formation on the inside and outside of the panel through the relatively lower strength slurry in the previous panel. This provides continuity of the vibrated beam barrier wall throughout each panel joint.

Quality assurance and quality control (QA/QC) measures implemented to measure the quality of the vibrated beam barrier wall technology are well proven and have been implemented as part of construction of many successful barrier walls. Implemented QA/QC measures will include manufacturer's quality assurance (MQA), manufacturer's quality control (MQC), construction quality assurance (CQA), and construction quality control (CQC). MQA and MQC will be implemented by manufacturers to measure the quality of manufactured products used to construct the barrier wall, such as attapulgite and cement additives. CQA and CQC inspection, sampling, field testing, and laboratory testing will be implemented to measure the quality of the vibrated beam barrier wall as it is constructed. CQA/CQC procedures are generally described in the response to Comment 11 above. The QA/QC organization, inspection and sampling frequency and methods, field and laboratory test methods, and acceptance criteria will be described in a CQA plan prepared for construction of the barrier wall for this site (if a vibrated beam slurry wall is selected). Results of the MQA, MQC, CQA, and CQC inspection and testing will be reported in a construction completion report.

In addition, an excerpt apparently from the "Lock E Test Program, Tennessee-Tombigbee Waterway", December 1978 described a problem penetrating sandstone, including belts breaking on the

vibratory hammer. As no sandstone or similarly consolidated material is planned to be penetrated by the proposed vibrated beam barrier wall, that reported problem is not relevant.

A second reported problem was that the working platform, reported to be silty clayey gravel, was rutted by the construction equipment. As the proposed barrier wall will be constructed on stable fill material sloped to drain to a slurry reservoir trench, accumulation of slurry to any significant depth on the working platform, and associated rutting, is not expected to be as much a problem as reported. Problems reported with pumping from wells near piezometers, and lack of drawdown, appeared to indicate problems with the piezometers, not the barrier wall. Whereas the report stated that the observation of large aggregate (size not stated) "left little doubt as to the impermeability [assumed to mean assumed high permeability of that barrier wall] of this type of wall [i.e. the Portland cement slurry vibrated beam technology] in alluvium sand and gravel," no reliable performance data were provided to support that statement. Also, as neither gravel nor cobbles are present within the proposed barrier wall route, the problem reported with "large aggregate" protruding through the barrier wall is not relevant to the proposed barrier wall.

Description of the vibrated beam technology reported in "Memorandum for ED-F File, Subject: Performance of the Vibrated Beam Slurry Cutoff Walls", D. Karns, supports use of the vibrated beam as a barrier wall technology. For example, effectiveness of the vibrated beam barrier wall constructed as floodwall protection cutoff in Caruthersville, Missouri, was described as "seepage seems to be reduced." The problem described with that project of the beam remaining plumb could be associated with the fin following an initial boring that may have deviated from vertical due to obstructions deflecting the relatively thin and long drill string, and the vibrated beam fin correctly following the path opened by the drill string. This would create a barrier wall that might be slightly out-of-plumb, but nonetheless continuous and effective. Similarly, discontinuities reported are probably due to deviation of the sample boring from the path of the vibrated beam barrier wall rather than discontinuities of

the barrier wall. Objections were based on indirect observations rather than performance data.

The vibrated beam barrier wall described as being constructed at the Riverview Disposal Area, Holland, Michigan, was reported to have achieved permeability test acceptance criteria, and the landfill was reported to be confident that the vibrated beam barrier wall was effective, as shown by accumulation of liquid in the containment area. The landfill operator was reported to consider the vibrated beam barrier wall technology to be a good construction method, and was "very satisfied with the results."

The vibrated beam barrier wall constructed for temporary construction dewatering at the Oakes Pumping Station, Oakes, North Dakota, was reported to have "performed satisfactorily."

The operator of a landfill in Houston, Texas, at which a vibrated beam barrier wall was constructed to contain landfill waste at the landfill, was reported to have "expressed confidence in the vibrated beam slurry cutoff."

In the Comptroller General Decision document, File B-212033, Comptroller General of the United States, December 13, 1983, the stated objection that "only indirect methods [can be used] to ensure that the wall is properly placed in the soil" are also applicable to conventional slurry trench and sheet pile barrier walls, in addition to other possible barrier wall technologies (e.g., auger soil mixing and jet grouting).

Furthermore, the objection that the vibrated beam barrier wall technology was not tested for compatibility with site-specific leachate does not apply to use of the vibrated beam barrier wall technology at the Arkema site as a comprehensive suite of compatibility tests were performed using affected ground water, including DNAPL, from the site (see Appendix C of the FFS). The results of the Arkema site slurry materials testing showed that the candidate slurry materials, including the "Impermix" slurry that could be used to construct the barrier wall using the vibrated beam barrier wall technology, are compatible with samples of affected soil,

ground water, and DNAPL expected to be encountered by the barrier wall constructed at the Arkema site.

In the excerpt from "Investigation of Impervious Cutoff, Caruthersville, Missouri," Foundations and Materials Branch, May 1978, objections to the vibrated beam barrier wall are accompanied by the note that "this is not to say that the wall is ineffective." Results of further tests, if implemented, were not included in the document. Consequently, the objections to use of the vibrated beam barrier wall are speculative.

In the "Disposition Form" re; MRDED-G, Inspection of Harry S. Truman Dam, (unknown) Redlinger, Chief, GS&M Branch, the vibrated beam barrier wall was described as being used in lieu of an apparent conventional slurry trench and backfill barrier wall due to excess loss of slurry using the conventional technique. The problems described constructing the barrier wall are not relevant to construction of the barrier wall at the Arkema site due to the presence of gravel at the Harry S. Truman dam site. Further, the project at the Harry S. Truman dam site was reported to have been constructed using "Aspemix" cold asphalt emulsion, which is not proposed for construction of the vibrated beam barrier wall for the Arkema Portland site.

In summary, the reported problems appear to be the result of conditions that will not be encountered during construction of a potential vibrated beam barrier wall at the Arkema site. Consequently, use of the vibrated beam barrier wall technology is considered one of two appropriate and cost-effective technology options for the IRM proposed at the Arkema site.

6. *Page 40, Section 4.4.2 Ex Situ Groundwater Treatment Technologies, Air emission control technologies – Air emission control technologies will need to be employed or LSS needs to demonstrate that the implementation risk (OAR 340-340-122-0090(3)(d) is acceptable. See DEQ Guidance for Managing Hazardous Air Discharges from Remediation Systems at http://www.deq.state.or.us/lq/pubs/docs/cu/GuidanceManageingHazAirDischarge.pdf.*

Comment noted.

7. *Figure 6-1 – The project schedule needs to include 60 days for public notice and comment.*

   Comment noted. A revised project schedule that reflects a 60-day comment period for the FFS is attached.

8. *Figure 6-1 – A meeting will need to be schedule to discuss the proposed project schedule and consideration of options for compressing it.*

   Comment noted. LSS has regular monthly meetings with ODEQ.

9. *Table 4-1 – For the action to be consistent with the long-term remedial action for the Portland Harbor Superfund Site, the table of preliminary project ARARs needs to be modified to address the following comments:*

   1. *Identify CERCLA and the NCP as an ARAR.*
   2. *The Federal Water Pollution Control Act, Section 401, is applicable to both the construction of the wall if done in waters of the US as well as its performance to eliminate contaminated groundwater from discharging to the Willamette River. Section 304, the recommended ambient water quality standards, are relevant and appropriate to performance of the containment system and quality of groundwater discharging to the river.*
   3. *Endangered Species Act – ESA regulations are potentially applicable depending on the barrier wall location.*
   4. *Safe Drinking Water Act – The Safe Drinking Water Act is relevant and appropriate for CERCLA groundwater and surface water cleanups.*
   5. *Oregon Water Quality Law – Remove the words likely and may from the applicability column.*
   6. *Oregon Regulations Pertaining to NPDES and WPCF Permits – Remove the word potentially from the applicability column.*
   7. *Oregon Underground Injection Control Rules - Remove the word potentially from the applicability column.*
   8. *Oregon Solid Waste Management Act - Remove the word potentially from the applicability column.*
   9. *Cleanup Standards – Change the phrase "may be applicable" to "is applicable" from the applicability column.*

1. Comment Noted

2. LSS agrees Section 401 is an ARAR to the extent the wall is constructed in US waters. Section 304 is an ARAR to the extent that the point of compliance is surface water.

3. The Endangered Species Act (ESA) is an ARAR only to the extent that the wall impacts or potentially impacts a threatened or endangered species. Based on the proposed location of the wall, there is no loss of habitat and therefore no jeopardy from the project is anticipated. Therefore, the ESA is not considered an ARAR.

4. The Safe Drinking Water Act (SDWA) is an ARAR to the extent that the point of compliance is a drinking water source. We do not anticipate a nexus to drinking water at this site, and therefore the SDWA is not considered an ARAR.

5. Comment noted.

6. Comment noted.

7. Comment noted.

8. Comment noted.

9. Cleanup standards are applicable to the extent that, in addition to hydraulic gradient control, cleanup standards are established for the site.

Appendix A – Groundwater Modeling Report Comments

General Comments

1. *Most of the figures indicate two adjacent groundwater mounds occurring at Lot 4. The source of this mound and its anticipated longevity should be described in the text. An analysis should be provided that considers changes in the hydraulics and capture if the mound changes.*

Measured groundwater levels in the Shallow Zone monitoring wells show some groundwater mounding around monitoring wells MW-33 and MW-39 near the Chlorate Cell room (See Figure 4-2 in the Draft Groundwater Modeling Report [ERM, 2007]). There are several sumps along the east and south sides of the Chlorate Cell room, which are approximately 10 ft deep and drain most of Chlorate cell room via a series of trenches. The cause of the mounding in the Shallow Zone near the Chlorate Cell room is unknown, but may be due to leakage of water from the sumps. Leakage from the sumps was simulated in the model with head-dependent flow boundaries and these boundaries produce the mounding in the head solution of the model.

The mounding in the model head solutions is localized around the sumps and does not significantly increase the hydraulic gradient toward the Willamette River. Therefore, the mounding is not anticipated to have any significant effect on the performance of the barrier wall systems.

2. *Riverfront Alignment of Wells for Full Enclosure Groundwater Barrier Wall - In the full encompassing wall scenario, it's not clear that a riverfront alignment of extraction wells is necessary or optimal. At the McCormick and Baxter site, gradients flattened out within the barrier wall, and the leakiest portion of the barrier is not along the downstream wall of the containment area. The primary function of the extraction wells is to prevent leakage through the barrier system. In the absence of gradient, wells can reduce leakage more effectively by locating them in areas where leakage is anticipated (i.e. locations where barrier wall-basalt contact is uneven), which may or may not coincide with riverfront areas.*

   What is the objective with regards to water table elevations inside and outside the fully encompassing barrier? Is it to depress the water table within the containment barrier, maintaining a slight inward gradient? What is the magnitude of the design gradient?

   LSS notes that the barrier wall at the McCormick and Baxter is not comparable to either of the proposed barrier wall alignments at the Arkema site as the McCormick and Baxter wall does not extend to the top of basalt, but rather "hangs" in the units above. Although LSS is not familiar with the hydrologic characteristics of the zone

into which the McCormick and Baxter wall is keyed, it is clear that at this time, comparisons between the two hydrologic systems are not valid given the very different geologic units contained by the two walls.

The objectives in the fully encompassing barrier wall simulations were to minimize groundwater mounding inside the wall and to maintain an inward gradient toward the withdrawal wells that was sufficient to capture groundwater in the fractured basalt (layer 6) that might flow under the wall.

Specific Comments

1. *Page 4 Section 3.1 Simulation of Groundwater Barrier Walls and Upgradient Withdrawal Wells - In the fully enclosed barrier wall scenario, Table A.3-1 indicates that between 92 and 112 gpm of water would have to be pumped to meet the goals of full containment and minimal mounding within the barrier. Based on the conceptual, it is not clear to this reviewer where this 92 -112 gpm is coming from under long-term steady-state conditions. The barrier, as described in the report and depicted in Figures 4-2, 4-4 and 4-8 is a fully encompassing and fully penetrating. The bottom of the barrier contacts the underlying basalt, which is effectively treated as a no flow boundary. In the model there are 3 boundaries through which water can flow: 1) the barrier wall, 2), the surface of the containment area (precipitation recharge), and 3) the basalt contact. The following items represent the different contributing sources under a long-term, steady-state condition.*

   - *Based on the barrier dimensions, specified hydraulic conductivity, and 2 feet of head difference across the barrier width (the maximum depicted in Figure A.3-21), seepage rates are approximately 2,285 gal/day or 1.6 gpm.*
   - *Although, the report does not indicate the assumed rate of precipitation recharge, in comments to Arkema on the Draft Groundwater Modeling Report, DEQ suggested a value of 80% of the annual average precipitation of 37.4 inches or approximately 30 inches/yr. Assuming 30 inches of recharge over approximately 50% of the enclosed area (discounting impervious areas - roughly 9 acres) yields an average daily input of 20,000 gallons/day or 14 gpm.*

- *In the Draft Modeling Report, a downward gradient is presumed in the basalt, and the report states that downward flow through this unit is insignificant. Although not quantified, upward flow from the basalt into the containment area is also assumed to be negligible.*

Based on this accounting of water inputs, the long term pumping rate appears to be closer to 20 gpm than 100 gpm. For comparison, DEQ reviewed data collected at the McCormick and Baxter site where a fully encompassing, partial-fully penetrating barrier wall was installed near the Arkema facility. The hydrologic and hydrogeologic settings, and the location and size of the containment areas at the McCormick and Baxter and Arkema sites are very similar. In the seven years since the wall was installed at the McCormick and Baxter property, no groundwater extraction wells have operated at the site and groundwater has never over-topped the barrier. In addition, after construction of a RCRA cap, which significantly reduced surface infiltration, groundwater elevations within the containment area have dropped, and in some cases are five feet lower than those measured in adjacent locations outside the wall.

Long-term pumping rates figure prominently in the feasibility analysis and alternative cost comparisons. It appears that long-term pumping rates for the fully encompassing barrier wall may have been significantly overestimated, resulting in an inaccurate cost comparison to other remedial alternatives.

As stated in the response to Comment 2 above, LSS notes that the barrier wall at the McCormick and Baxter is not comparable to either of the proposed barrier wall alignments at the Arkema site as the McCormick and Baxter wall does not extend to the top of basalt, but rather "hangs" in the units above. Although LSS is not familiar with the hydrologic characteristics of the zone into which the McCormick and Baxter wall is keyed, it is clear that at this time, comparisons between the two hydrologic systems are not valid given the very different geologic units contained by the two walls.

As noted in the comment, the McCormick and Baxter wall is "partial-fully penetrating." As such, it is possible that water is "flushing" out the bottom of the wall, thus resulting in the lowered water levels and eliminating the need for extensive pumping. As the proposed Arkema wall is correctly noted as being fully penetrating, flushing

out beneath the bottom of the wall is not a viable option and pumping will be required.

It should also be noted that the required pumping rate (Q) for the fully-enclosed barrier wall scenario is driven by the permeability of the fractured (Layer 6) and unfractured (Layer 7) basalt (not flow through the wall, over the wall, or precipitation). In developing the groundwater model, ERM used a conservative permeability for the basalt layers for all scenarios. A hydraulic conductivity (Kh) value of 10 feet/day was used for the fractured basalt. The rationale for this value is as follows:

- The single well pump test performed when Well MWA-21b was installed derived a Kh value of approximately 1 foot/day. In ERM's professional experience, single well pump tests tend to underestimate permeability by an order of magnitude, especially taking into consideration the short test time and the fact it was a single well test. Therefore, a value of 10 ft/day was used for the fractured basalt. A value of 2.5 ft/day was used for the underlying unfractured basalt.

- Permeabilities of basalt, and especially fractured basalt, are of course highly variable. Therefore, a conservative assumption was considered prudent.

- For comparison purposes, in the Rhone Poulenc model, an average Kh value of 5.7 feet/day was used for the basalt layer (unclear if this is the fractured, unfractured, or an average of both). This value was based on six aquifer tests (range of 1.1 to 15 feet/day).

It should be further noted the barrier wall would be installed only to the top of the fractured basalt, and not "keyed" into this zone. The fractured basalt and underlying unweathered basalt are not assumed to be no flow boundaries in the model.

2. *Page 8, Section 3.2.4 – Currently the analysis of reinjection focuses on mounding and effects of the containment at the barrier wall. The analysis*

also needs to include an evaluation on how the proposed discharge may change (e.g., accelerate) the migration of existing contamination.

Reinjection could potentially be performed upgradient of groundwater extraction system (i.e., within the capture zone of the groundwater extraction system) and/or outside the containment area. The benefit of upgradient injection would be to allow introduction of an amendment that would enhance in situ treatment of groundwater. The benefit of injection outside the hydraulic capture zone would be to discharge water without adversely affecting the extraction system.

Reinjection of treated groundwater, if performed, will not impact contaminant migration by either: 1) introducing new contaminants into the injection area, or 2) increasing the migration and mobilization of existing contaminants in the injection area. Obviously, neither of these potential impacts are of concern if reinjection occurs upgradient and within the groundwater capture zone.

Regarding reinjection outside of the proposed capture zone, the treated groundwater discharge from the ex situ treatment system is expected to only have very low concentrations, if any, of contaminants present. The planned multi-process ex situ treatment system is robust and will treat site constituents of concern (COCs) to very low levels (well below MCLs). At these low levels, it is not expected that significant contaminant mass would be added to the injection area. Although chloride will not be removed as part of the ex situ treatment process, expected concentrations of chloride in the treated discharge (approximately 1,600 milligrams per liter according to the groundwater treatability study [Adventus 2008]) are similar to those encountered in the shallow and intermediate aquifers across the site. Therefore, injection of the treated water stream is not expected to exacerbate or worsen chloride concentrations in groundwater.

Regarding the potential for increasing migration of contaminants within the capture zone, this is not a concern. For injection outside the capture zone (e.g., Lots 1 and 2), contaminant impacts to the

shallow aquifers are very minimal in these areas and therefore negative effects from injection of treated water are not expected.

3. *Figure A.3-6, Figure A.3-6 suggests a hydraulic gradient would remain within the containment area of a fully encompassing barrier without groundwater pumping. The barrier wall should effectively isolate the containment area from the surrounding groundwater flow system including hydraulic gradients, thus DEQ expects there would be no gradient within the containment area. Again, DEQ reviewed data from McCormick and Baxter which indicate gradients within the containment area are effectively flat.*

   As stated in the response to Comment 2 above, LSS notes that the barrier wall at the McCormick and Baxter is not comparable to either of the proposed barrier wall alignments at the Arkema site as the McCormick and Baxter wall does not extend to the top of basalt, but rather "hangs" in the units above. Although LSS is not familiar with the hydrologic characteristics of the zone into which the McCormick and Baxter wall is keyed, it is clear that at this time, comparisons between the two hydrologic systems are not valid given the very different geologic units contained by the two walls.

   The hydraulic conductivity of the fractured basalt (layer 6) in the model was conservatively estimated to be 10 feet/day as discussed above. The hydraulic conductivities from these tests ranged between 1.1 and 15 ft/day, with an average hydraulic conductivity of 5.7 ft/day (Table 4 of Groundwater Transport Evaluation Report, RP-Portland Site [AMEC 2005]). The pumping tests of the basalt on the RP site indicate that the upper portion of the basalt (weathered and fractured zone) in this area does have permeability greater than zero. Therefore, as the model simulations show, a barrier wall installed to the top of the basalt may not alone effectively isolate the containment area, and ground water extraction would be required to prevent groundwater flow under the wall within the fractured basalt.

4. *Figures A.3-13 through A.3-18- Based on groundwater contour map of site, the model-runs used to create Figures A.3-13 through A.3-18 do not appear*

to designate a no-flow/low-flow boundary on the upgradient side of the fully encompassing containment barrier. Groundwater elevation contour lines cross the barrier and appear to be unaffected by the presence of the wall. In contrast the contour lines depicted in Figures A.3-21 and A.3-22 show parallel orientation to the barrier in places and a marked elevation difference across the barrier.

The model head solutions shown in Figures A.3-13 through A.3-18 in the FFS are incorrect. The correct flow path solutions are provided in Attachment C. The revised figures do not change any of the model outputs or conclusions.

5. *Tables A.3-1 and A.3-2 – On comparison of these two tables it appears that pumping rates are different than injection rates. A pumping rate should be the same as the injection rate for each simulation unless water was being discharged to some other point (e.g., the river). The tables should be revised to reflect equivalent pumping/injection rates, or a note should be included to explain the difference.*

   The pumping rate was the same as the injection rate for each simulation. As described in Section A.3.2.3, pumping was simulated from withdrawal wells in the Shallow Zone (layer 1) and Intermediate Zone (layer 3). Therefore, in Table A.3-1 the total pumping rates are the sum of the pumping rates of the Shallow and Intermediate Zone wells for each simulation. These total pumping rates are equal to the total injection rates shown in Table A.3-2.

6. *Maintaining Integrity of the Barrier Wall - Piping can be a concern with slurry walls. What guidelines are being used to manage gradients to prevent this from occurring? Are there prescribed distances for setting the extraction wells back from the slurry wall to prevent exposure of the wall to strong hydraulic gradients?*

   In the model simulations, the withdrawal wells were placed at least 37 feet away from the barrier wall. The head difference between the wall and the wells ranged from approximately 2 to 4 feet. This would result in hydraulic gradients near the wall in the range of 0.05 to 0.11 ft/ft. These gradients are very low and should not impact the integrity of the wall.

A conventional slurry trench wall will have width adequate to reduce the resulting gradient to a low enough value that transport of fines will not result, especially as the clay in the slurry wall will swell and effectively plug voids in the adjacent native soil matrix. A vibrated beam slurry wall constructed using "Impermix" clay cement will result in a durable structure that will be very resistant to piping. No measures other than conventional construction techniques should be required.

7. *Reinjection of Extracted Groundwater on Lots 3 and 4 - Figures A.3-23, 24, 25 and 26 – Show the results of simulating groundwater injection on Lots 2, 3 and 4. While the figures show significant hydraulic mounding associated with re-injection on Lot 2, virtually none occurs on Lots 3 and 4 even when combined injection rates exceed 100 gpm. Please confirm that the figures are accurate and elaborate further (beyond the discussion in Section 3.2.4 of Appendix A) on the hydrogeological conditions that produce these disparate results.*

   The model head solutions shown in Figures A.3-23, 24, 25 and 26 are accurate. A paleotopographic high (topographic high on the top of the basalt) underlies Lot 2 and the overlying sediments, including the Shallow Zone and Intermediate Zone, are much thinner in this area than in Lots 3 and 4 (See Figure 6-3 in the Draft Groundwater Modeling Report [ERM, 2007]). Because the Shallow Zone and Intermediate Zone are much thinner in Lot 2 they have correspondingly lower transmissivities and more mounding occurs as a result of injection.

8. *Presentation of Capture Zones - To help clarify the conceptual site model for active hydraulic containment systems, DEQ requests that extraction well capture zones be depicted in cross-section in addition to the plan view presentations and that capture zones and flow lines extend to any relevant horizontal or vertical barrier or boundary to groundwater flow.*

   As noted in Section A.3.2.2, three-dimensional visualizations of the results of the barrier wall simulations shown in Figures A.3-7, A.3-8 and A.3-9 were included in Appendix A along with an interactive viewer.

Appendix B – Geotechnical Evaluation Report Comments
General Comments

1. *The evaluation report is lacking in describing the various slope stability alternatives. There appear to be inconsistencies; however, these may be explained by a thorough description of the assumptions and results. For example, it appears that the barrier wall can be placed with 8 to 10 feet of the top of bank and not significantly reduce stability, but the analysis is not conducted with the construction loading for this case. Another issue is that the assumed strength for the soil units varies from one analysis to another. Another example is the analysis for the pilot trench, which does not really address trench stability, but just confirms that the critical failure surface for the bank extends about 10 feet back from the top.*

   A summary of required setbacks from the TOB for the various barrier wall options and clearance trench are discussed in the response to Comment 2 above and summarized in Table H-1 attached to this response to comments.

   The soil parameters employed in the analyses were selected to remain constant. However, multiple analytical solutions were performed, and it is possible incorrect back-up results are provided in the FFS. A complete set of correct solutions is provided in Attachment D and should replace those provided in Appendix B of the FFS.

Specific Comments

1. *Page 2, Table (Index Properties): There are no backup calculations for the selected strength parameters. A special concern is assigning Soil Zone 1 ("Sand") a cohesion value of 180 psf (8.6 kPa) and Soil Zone 2 ("Sandy Silt") a cohesion value of 416 psf (20 kPa). Atterberg limits for these soils are non-plastic. In addition, the parameters for Soil Zone 1 vary with differing slope stability analyses. Parameters are used in the analyses for the slurry wall material, but there is no description of the parameters or how they were developed in the text.*

   Soil parameters used in the analyses are based on a correlation of index properties from the borings conducted on the site to similar materials at other sites for which specific analytical data is available. As indicated in the soil descriptions, a mixture of particle sizes and

materials was apparent in each of the soil layers, varying from sands to silts, and in the surficial layer, including fill material. While the Atterberg Limits for several of these materials may have indicated cohesion-less properties, their performance is more accurately determined through strength testing for each material type. In the absence of specific data from the site, the materials were correlated through index properties to other materials of similar description for which data was available. Given the mixed nature of the soil particles, the inclusion of silts, and the presence of fill materials, some "apparent" cohesion could be expected. Nevertheless, to off-set this cohesion, somewhat more conservative φ– angles were adopted than would be assigned to a solely cohesion-less material. The analyses can be performed with adjusted strength parameters, but it is suggested that this refinement be conducted using actual data results on samples derived from the site during the design phase.

The properties used for the slurry materials were derived from literature and vendor experience, and similarly would be refined as necessary during the design phase once the installation process is selected.

2. *Page 3, Analyses (General): Please explain why similar strength parameters were used for long term and rapid drawdown conditions. Typically, drained strength parameters are used for long-term analyses and undrained strength parameters (or even more complex strength models) are used for short term (such as rapid drawdown) conditions.*

The groundwater level at the site is understood to be relatively constant; therefore, the materials beneath this level will be saturated at all times. The location of the static groundwater table was included in the analyses as a piezometric surface in the program geometry at a constant elevation consistent with the surface-water elevation in the river. In reality, this may be a simplifying assumption, but supports an approximation of the relative stability of the slopes. The drained condition would not reasonably be expected to occur except in the event of dewatering of the soils during construction, which is not anticipated, and in the surficial unsaturated zone. Further, while a reduction in the pool elevation in

the river would theoretically draw down the phreatic surface in the near bank slope over time, this situation is not anticipated and therefore was not analyzed.

For the rapid drawdown scenario, the river pool elevation was reduced to the streambed elevation for the river while the remaining piezometric level in the groundwater was retained as constant. In this scenario, the soils would remain saturated instantaneously while the resisting load at the toe of the river bank was removed. Therefore, for that point in time, the soil parameters would not change, only the down slope resisting force of the river; it is recognized that with time, the phreatic surface would adjust to the reduced level in the river pool elevation, resulting in a drained condition above the modified phreatic surface. This situation may be analyzed when site-specific soil strength properties become available. For the current analyses, the only adjustment is the configuration of the piezometric level.

The soil parameters were derived from similar materials for which actual analyses were available and correlated to the site through a comparison of index properties. For this initial analysis, these properties permit an approximation of the performance of slopes at the site; subsequent detailed design analyses will require site-specific data and more comprehensive analyses.

3. *Page 3, Analyses (General): The text indicates that STABL2.2 was used for the slope stability analyses; however, the computer printouts provided indicate that PCSTABL 6 was used. Please explain the discrepancy.*

   STABL is a computer program written in FORTRAN and developed at Purdue University for the general solution of slope stability problems by two-dimensional limiting equilibrium methods. The broad-based STABL program has variants used in differing applications, but the capabilities are all similar. Versions of the program subsequent to the original often indicate the version number (2.2). PCSTABL6 is a PC-based version of the STABL computer program, and was the application used to perform the analyses. The references in the text can be clarified to only reflect the PCSTABL6 terminology.

Sincerely,

Todd Slater
Legacy Site Services LLC

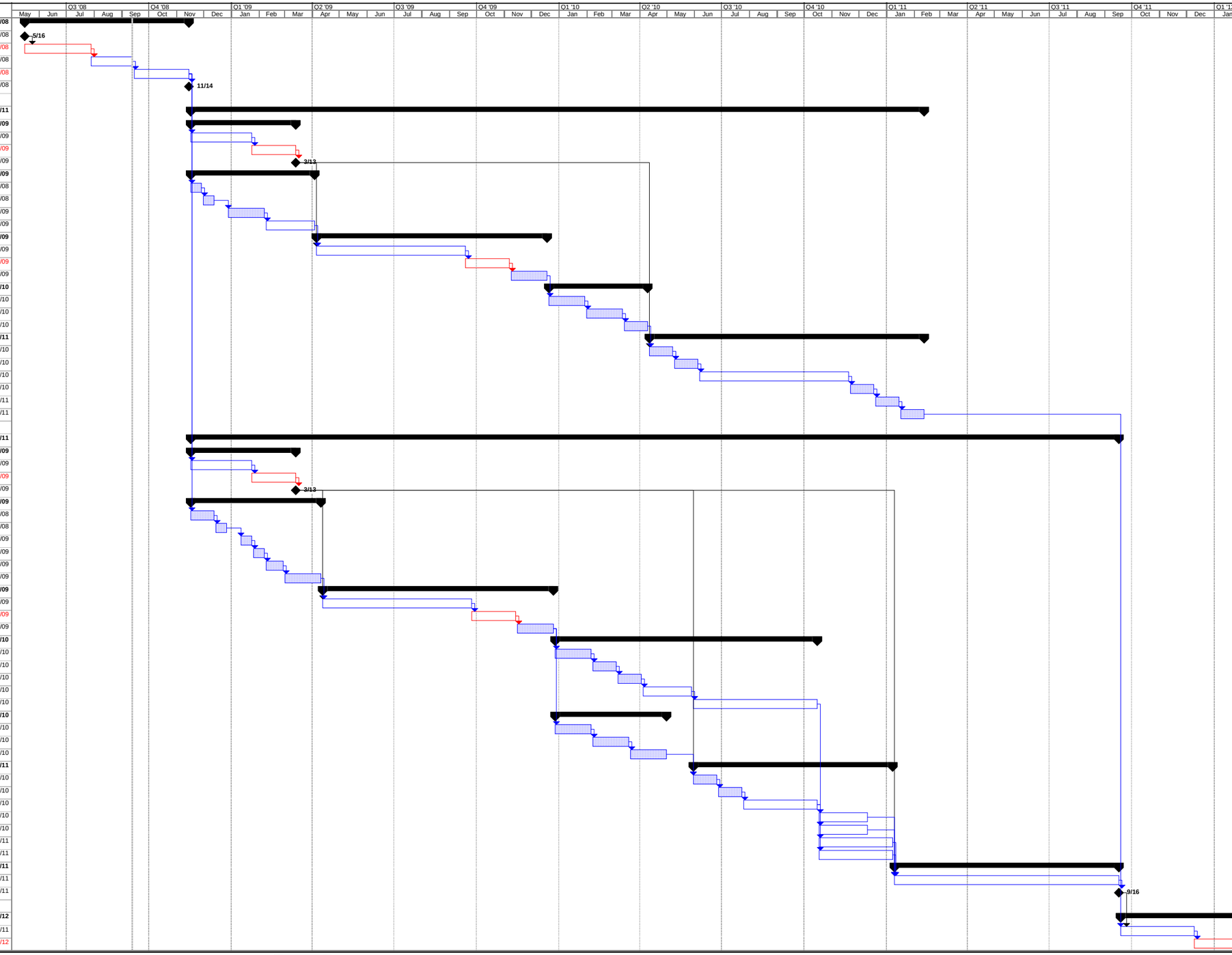
Attachments

cc: Sean Sheldrake, EPA
Lance Peterson, CDM
Tom Gainer, DEQ
Henning Larsen, DEQ
Steve Parkinson, Groff Murphy
Erik Ipsen, ERM
Larry Patterson, ERM
David Livermore, Integral

Figures

FIGURE 6-1
Preliminary Implementation Schedule
Groundwater Source Control Interim Remedial Measure
Arkema Chemicals Facility - Portland, Oregon

ID	Task Name	Duration	Start	Finish
1	**Focused Feasibility Study Report**	**131 days**	**Fri 5/16/08**	**Fri 11/14/08**
2	Submit to ODEQ/EPA	0 days	Fri 5/16/08	Fri 5/16/08
3	ODEQ/EPA Review	74 edays	Fri 5/16/08	Tue 7/29/08
4	LSS Response to Comments	34 days	Tue 7/29/08	Fri 9/12/08
5	60-Day Public Review and Comment	45 days	Mon 9/15/08	Fri 11/14/08
6	Agency Approval	0 days	Fri 11/14/08	Fri 11/14/08
7				
8	**Groundwater Barrier Wall**	**585 days**	**Mon 11/17/08**	**Fri 2/11/11**
9	**GWBW Permitting**	**85 days**	**Mon 11/17/08**	**Fri 3/13/09**
10	Application Preparation	50 days	Mon 11/17/08	Fri 1/23/09
11	ODEQ/EPA Review	49 edays	Fri 1/23/09	Fri 3/13/09
12	Permits Issued	0 days	Fri 3/13/09	Fri 3/13/09
13	**GWBW Pre-Design Investigation**	**100 days**	**Mon 11/17/08**	**Fri 4/3/09**
14	PDI Scoping	10 days	Mon 11/17/08	Fri 11/28/08
15	Surveyor and Driller Contracting	10 days	Mon 12/1/08	Fri 12/12/08
16	Route Survey Field Work/Data Evaluation	30 days	Mon 12/29/08	Fri 2/6/09
17	Route CPT and Borings Field Work/Data Evaluation	40 days	Mon 2/9/09	Fri 4/3/09
18	**GWBW Design**	**185 days**	**Mon 4/6/09**	**Fri 12/18/09**
19	Pre-Final Design Preparation and Submittal	120 days	Mon 4/6/09	Fri 9/18/09
20	ODEQ/EPA review and approval	49 edays	Fri 9/18/09	Fri 11/6/09
21	Final Design Preparation	30 days	Mon 11/9/09	Fri 12/18/09
22	**GWBW Bidding and Contracting**	**80 days**	**Mon 12/21/09**	**Fri 4/9/10**
23	Bid Package Preparation	30 days	Mon 12/21/09	Fri 1/29/10
24	Contractor Bidding	30 days	Mon 2/1/10	Fri 3/12/10
25	Bid Review, Selection, and Contract Execution	20 days	Mon 3/15/10	Fri 4/9/10
26	**GWBW Construction**	**220 days**	**Mon 4/12/10**	**Fri 2/11/11**
27	Mobilization and Site Preparation	20 days	Mon 4/12/10	Fri 5/7/10
28	Surface and Route Clearance	20 days	Mon 5/10/10	Fri 6/4/10
29	GWBW Construction	120 days	Mon 6/7/10	Fri 11/19/10
30	GWBW Cap Construction	20 days	Mon 11/22/10	Fri 12/17/10
31	GWBW Piezometer Construction	20 days	Mon 12/20/10	Fri 1/14/11
32	Demobilization	20 days	Mon 1/17/11	Fri 2/11/11
33				
34	**Groundwater Extraction & Treatment System**	**740 days**	**Mon 11/17/08**	**Fri 9/16/11**
35	**GWTS Permitting**	**85 days**	**Mon 11/17/08**	**Fri 3/13/09**
36	Application Preparation	50 days	Mon 11/17/08	Fri 1/23/09
37	ODEQ/EPA Review	49 edays	Fri 1/23/09	Fri 3/13/09
38	Permits Issued	0 days	Fri 3/13/09	Fri 3/13/09
39	**GWTS Pre-Design Investigation**	**105 days**	**Mon 11/17/08**	**Fri 4/10/09**
40	PDI Scoping	20 days	Mon 11/17/08	Fri 12/12/08
41	Surveyor and Driller Bidding and Contracting	10 days	Mon 12/15/08	Fri 12/26/08
42	Recovery Well Installation	10 days	Mon 1/12/09	Fri 1/23/09
43	Pumping Tests	10 days	Mon 1/26/09	Fri 2/6/09
44	Data Reduction and Evaluation	15 days	Mon 2/9/09	Fri 2/27/09
45	Confirmatory Ground Water Modeling	30 days	Mon 3/2/09	Fri 4/10/09
46	**GWTS Design**	**185 days**	**Mon 4/13/09**	**Fri 12/25/09**
47	Pre-Final Design Preparation and Submittal	120 days	Mon 4/13/09	Fri 9/25/09
48	ODEQ/EPA review and approval	49 edays	Fri 9/25/09	Fri 11/13/09
49	Final Design Preparation	30 days	Mon 11/16/09	Fri 12/25/09
50	**GWTS Equipment Procurement**	**210 days**	**Mon 12/28/09**	**Fri 10/15/10**
51	Bid Specifications Preparation	30 days	Mon 12/28/09	Fri 2/5/10
52	Vendor Bidding	20 days	Mon 2/8/10	Fri 3/5/10
53	Bid Evaluation, Selection, and PO Execution	20 days	Mon 3/8/10	Fri 4/2/10
54	Fabrication Drawing Preparation, Review, and Approval	40 days	Mon 4/5/10	Fri 5/28/10
55	Fabrication and Delivery	100 days	Mon 5/31/10	Fri 10/15/10
56	**GWTS Bidding and Contracting**	**90 days**	**Mon 12/28/09**	**Fri 4/30/10**
57	Bid Package Preparation	30 days	Mon 12/28/09	Fri 2/5/10
58	Bidding	30 days	Mon 2/8/10	Fri 3/19/10
59	Bid Review, Selection, and Contracting	30 days	Mon 3/22/10	Fri 4/30/10
60	**GWTS Construction**	**160 days**	**Mon 5/31/10**	**Fri 1/7/11**
61	Mobilization	20 days	Mon 5/31/10	Fri 6/25/10
62	Site Preparation	20 days	Mon 6/28/10	Fri 7/23/10
63	Treatment Equipment Building Construction	60 days	Mon 7/26/10	Fri 10/15/10
64	Utilities	40 days	Mon 10/18/10	Fri 12/10/10
65	Equipment Installation	40 days	Mon 10/18/10	Fri 12/10/10
66	Conveyance Piping/Conduit Trenching and Installation	60 days	Mon 10/18/10	Fri 1/7/11
67	Well Installation, Development, Pump Setting, and Wellhead Construction	60 days	Mon 10/18/10	Fri 1/7/11
68	**GWTS Operation & Maintenance**	**180 days**	**Mon 1/10/11**	**Fri 9/16/11**
69	Startup	180 days	Mon 1/10/11	Fri 9/16/11
70	Commence Routine O&M	0 days	Fri 9/16/11	Fri 9/16/11
71				
72	**Interim Remedial Measure Implementation Report**	**95 days**	**Mon 9/19/11**	**Fri 1/27/12**
73	Report Preparation and Submittal	60 days	Mon 9/19/11	Fri 12/9/11
74	ODEQ/EPA Review	49 edays	Fri 12/9/11	Fri 1/27/12



Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Tables

Table H-1

Summary of Required Setbacks for Barrier Wall Options
Groundwater Source Control IRM
Arkema Inc. - Portland, Oregon

			Approximate Required Setback from Top of Bank (center of trench/wall to TOB) [a]			
Structure	**Option**	**Depth**	**Based on Critical Static or Rapid Drawdown Slope Stability Analysis (No Construction Load) [b]**	**Based on Construction Load Slope Stability Analysis [c]**	**Based on Construction Equipment Clearance Requirements [d]**	**Overall Required Setback (Largest of Setbacks to Left)**
Clearance Trench [e]	-	25 feet [f]	25 feet [g]	N/A	8 feet	25 feet
Vibrated Beam Slurry Wall	Deep Zone Key	60 feet	8 feet	22 feet	6 feet	22 feet
	Total Depth to Basalt	90 feet	10 feet	12 feet	8 feet	12 feet
Slurry Trench Barrier Wall	Deep Zone Key	60 feet	10 feet	30 feet	10 feet	30 feet
	Total Depth to Basalt	90 feet	12 feet	30 feet	12 feet	30 feet
Sheet Pile Barrier Wall	Deep Zone Key	60 feet	8 feet	22 feet [h]	4 feet	22 feet
	Total Depth to Basalt	90 feet	10 feet	12 feet [h]	4 feet	12 feet

[a] - All setbacks shown are based on conceptual design data, including equipment sizes, loads, and soil properties. Data should be obtained during the final design investigation and a technology-specific slope stability analysis performed prior to final selection of the setback.

[b] - S.F. = 1.5, unless otherwise noted. After completion of construction; assumes no imposed static or dynamic loads.

[c] - S.F. = 1.5. Assumed live (construction) loads for all technologies are same for each option. Differences in setbacks result from installation configuration of equipment (slurry trench is installed directly beneath equipment; vibrated beam and sheet pile walls are installed at an offset).

[d] - Setbacks include space for a temporary 1-foot tall containment berm with 2H:1V side slopes on the river side of the work platform; spaces for the containment berm on the land side of the work platform is not critical to the setback from the river bank TOB.

[e] - The purpose of the clearance trench is to clear the barrier wall route of debris and to cap, remove, or relocate utilities, as necessary; a deeper clearance trench would be required for the vibrated beam and sheet pile wall options than for the slurry trench wall (debris can be removed during installation of slurry trench).

[f] - Depth is for vibrated beam and sheet pile wall options and is determined by average thickness of fill; shallower trench would be required for slurry trench wall option.

[g] - Setback based on assumed-stable (i.e. S.F. not calculated; probably near 1.0) 0.5H:1V slope of excavation, plus 1/2 of a 3-foot trench bottom, plus a 10-foot distance between the trench TOB and the river bank TOB; smaller setback could be achieved through utilization of trench boxes or temporary shoring.

[h] - The minimum assumed equipment installation offset for sheet piles assumed to be same as vibrated beam technology.

TOB - Top of bank

N/A - Not Analyzed

S.F. = Safety Factor

Table H-2

Compatibility of Barrier Wall Options with Possible Future Remedial Actions
Groundwater Source Control IRM
Arkema Inc. - Portland, Oregon

	Barrier Wall Technology		
Type of Remedial Action	**Vibrated Beam Slurry Wall**	**Slurry Trench Barrier Wall**	**Sheet Pile Barrier Wall**
Soil Remediation Technologies			
Capping	**Compatible** - Cap could be placed over top of barrier wall.	**Compatible** - Cap could be placed over top of barrier wall.	**Compatible** - Cap could be placed over top of barrier wall.
Excavation (above water table)	**Compatible** - Portion of slurry wall in the unsaturated zone does not contribute to the performance of the wall and could be excavated easily along with impacted soil.	**Compatible** - Portion of slurry wall in the unsaturated zone does not contribute to the performance of the wall and could be excavated easily along with impacted soil.	**Compatible** - Excavation could be performed up to sheet pile wall. Sheet piles could serve as cantilever-supported shoring if needed. Estimated maximum depth of allowable excavation against wall is 1/2 of total wall depth, assuming excavation on one side only (excavation on both sides would increase allowable excavation depth). Slope stability and shoring analysis would be required to determine exact depth to which excavation could be safely performed along the wall.
Excavation (below water table)	**Compatible** - It is considered unlikely that excavation will extend beneath the water table in the area of the barrier wall (20 to 25 ft bgs). However, slurry wall could be easily excavated along with impacted soil. During backfilling, low-permeable material (e.g., betonies clay) may need to be placed over top of the wall up to the high water table to prevent "over-topping."	**Compatible** - It is considered unlikely that excavation will extend beneath the water table in the area of the barrier wall (20 to 25 ft bgs). However, slurry wall could be easily excavated along with impacted soil. During backfilling, low-permeable material (e.g., betonies clay) may need to be placed over top of the wall up to the high water table to prevent "over-topping."	**Compatible** - It is considered unlikely that excavation will extend beneath the water table in the area of the barrier wall (20 to 25 ft bgs). However, excavation could be performed up to sheet pile wall. Sheet piles could serve as cantilever-supported shoring if needed. Estimated maximum depth of allowable excavation against wall is 1/2 of total wall depth, assuming excavation on one side only (excavation on both sides would increase allowable excavation depth). Slope stability and shoring analysis would be required to determine exact depth to which excavation could be safely performed along the wall.
Soil Vapor Extraction (SVE)	**Compatible** - There are no compatibility issues with vapor extraction and the barrier wall technology. However, as the vacuum radius of influence will not extend through a barrier wall, extraction wells would need to be placed accordingly.	**Compatible** - There are no compatibility issues with vapor extraction and the barrier wall technology. However, as the vacuum radius of influence will not extend through a barrier wall, extraction wells would need to be placed accordingly.	**Compatible** - There are no compatibility issues with vapor extraction and the barrier wall technology. However, as the vacuum radius of influence will not extend through a barrier wall, extraction wells would need to be placed accordingly.
Dual Phase Extraction (DPE)	**Compatible** - Same as air sparging and soil vapor extraction.	**Compatible** - Same as air sparging and soil vapor extraction.	**Compatible** - Same as air sparging and soil vapor extraction.
In Situ Thermal Remediation (electro-resistive heating, steam injection, radio frequency heating)	**Potentially Compatible** - Temperature effects upon slurry wall should be evaluated prior to implementation.	**Potentially Compatible** - Temperature effects upon slurry wall should be evaluated prior to implementation.	**Potentially Compatible** - As sheet piles could be conductive, compatibility with electro-resistive heating would need to be evaluated.
In Situ Solidification/Stabilization (S/S)	**Compatible** - Mixing augers or other in situ S/S technology can be easily installed adjacent to, and through (if necessary), a slurry wall.	**Compatible** - Mixing augers or other in situ S/S technology can be easily installed adjacent to, and through (if necessary), a slurry wall.	**Potentially Compatible** - Mixing augers or other in situ S/S technology can be installed adjacent to, but not through, a sheet pile wall.

Table H-2

Compatibility of Barrier Wall Options with Possible Future Remedial Actions
Groundwater Source Control IRM
Arkema Inc. - Portland, Oregon

	Barrier Wall Technology		
Type of Remedial Action	**Vibrated Beam Slurry Wall**	**Slurry Trench Barrier Wall**	**Sheet Pile Barrier Wall**
Groundwater Remedial Technologies			
Monitored Natural Attenuation	**Compatible**	**Compatible**	**Compatible**
Air Sparing	**Compatible** - There are no compatibility issues with the injection of air and the barrier wall technology. However, as the sparging radius of influence will not extend through a barrier wall, injection wells would need to be placed accordingly.	**Compatible** - There are no compatibility issues with the injection of air and the barrier wall technology. However, as the sparging radius of influence will not extend through a barrier wall, injection wells would need to be placed accordingly.	**Compatible** - There are no compatibility issues with the injection of air and the barrier wall technology. However, as the sparging radius of influence will not extend through a barrier wall, injection wells would need to be placed accordingly.
In Situ Anaerobic Bioremediation	**Compatible** - There are no compatibility issues with the injection of common bio-amendments and the barrier wall technology. However, as the injection radius of influence will not extend through a barrier wall, amendment injections would need to be placed accordingly.	**Compatible** - There are no compatibility issues with the injection of common bio-amendments and the barrier wall technology. However, as the injection radius of influence will not extend through a barrier wall, amendment injections would need to be placed accordingly.	**Compatible** - There are no compatibility issues with the injection of common bio-amendments and the barrier wall technology. However, as the injection radius of influence will not extend through a barrier wall, amendment injections would need to be placed accordingly.
In Situ Chemical Oxidation (ISCO)	**Compatible** - Commonly used oxidants are expected to be compatible with the slurry. However, as the injection radius of influence will not extend through a barrier wall, oxidant injections would need to be placed accordingly.	**Compatible** - Commonly used oxidants are expected to be compatible with the slurry. However, as the injection radius of influence will not extend through a barrier wall, oxidant injections would need to be placed accordingly.	**Potentially Compatible** - As oxidants are expected to be reactive with metals, compatibility should be evaluated prior to implementation. Due to the thickness of the pile wall, however, reactivity is not expected to be a significant issue. As the injection radius of influence will not extend through a barrier wall, oxidant injections would need to be placed accordingly.
In Situ Chemical Reduction (ISCR)	**Compatible** - Commonly used reductants are expected to be compatible with the slurry. However, as the injection radius of influence will not extend through a barrier wall, reductant injections would need to be placed accordingly.	**Compatible** - Commonly used reductants are expected to be compatible with the slurry. However, as the injection radius of influence will not extend through a barrier wall, reductant injections would need to be placed accordingly.	**Potentially Compatible** - As reductants are expected to be reactive with metals, compatibility should be evaluated prior to implementation. Due to the thickness of the pile wall, however, reactivity is not expected to be a significant issue. As the injection radius of influence will not extend through a barrier wall, reductant injections would need to be placed accordingly.
In Well Vapor Stripping	**Compatible** - There are no compatibility issues with in situ vapor stripping and the barrier wall technology. However, as the treatment radius of influence will not extend through a barrier wall, treatment wells would need to be placed accordingly.	**Compatible** - There are no compatibility issues with in situ vapor stripping and the barrier wall technology. However, as the treatment radius of influence will not extend through a barrier wall, treatment wells would need to be placed accordingly.	**Compatible** - There are no compatibility issues with in situ vapor stripping and the barrier wall technology. However, as the treatment radius of influence will not extend through a barrier wall, treatment wells would need to be placed accordingly.
Pump and Treat (P&T)	**Compatible**	**Compatible**	**Compatible**
Dual Phase Extraction (DPE)	**Compatible** - Same as air sparging and soil vapor extraction.	**Compatible** - Same as air sparging and soil vapor extraction.	**Compatible** - Same as air sparging and soil vapor extraction.

bgs - Below ground surface

Table 5-1 (REVISED)

Evaluation Summary for Groundwater Barrier Wall Alternatives

Groundwater Source Control IRM

Arkema Inc. - Portland, Oregon

Barrier Wall Configuration	Barrier Wall Technology	Barrier Wall Depth	Effectiveness	Score	Long-Term Reliability	Score	Implementability	Score	Implementation Risk	Score	Reasonableness of Cost	Score	Summary of Evaluation	Average Score
River Side High Bank Route	Vibrated Beam Slurry Wall	T.D. at Basalt	• Reduces risk posed by affected media left in place. • Some potentially affected residuals left on the river side of the barrier wall. • Small amount of RA construction affected residuals. • Hydraulic conductivity of cured clay-cement plastic concrete sample was greater than for soil-slurry backfill, but adequately low to accomplish control of affected groundwater. • Effective immediately after completion of RA construction.	3	• Permanent control. • Few long-term uncertainties. • Compatible with site soils. • Hydraulic conductivity of clay-cement shown to be stable for control of affected ground water based on pore volume of each affected groundwater sample used as permeants. • Little apparent additional seismic risk compared to current condition. • Compatible with reasonable range of future in water actions (i.e. river bank regrading, capping, sediment dredging, sediment capping).	3.5	• Practical at this location. • No important technical difficulties. • No known legal difficulties. • Proven technology with few unknowns; the single major contractor in the US is a well-established diversified company with well-maintained commercially manufactured equipment. • Can be monitored with piezometers. • Consistent with federal, state and local requirements. • No special authorization required. • Services, materials, equipment, and specialists are commercially available. • Clearance of subsurface objects > 4-inch maximum dimension. • Uses proven CQA/CQC inspection and testing to measure quality of construction.	3.5	• No significant impacts on community. • Little potential for adverse impact on workers. • Worker PPE and work procedures address worker risks. • Low potential for adverse impact on environment, such as release of residuals to the river. • Simple and reliable controls address potential adverse risk on environment. • Vibration expected to be insignificant off site; may need more study. • Effective immediately on completion of RA construction and start-up of GWE and treatment components of RA.	3	• Low-range capital cost. • No O&M cost. • No special periodic review needed. • NPV = $9,500,000	3	• Good effectiveness. • Very good reliability. • Very good implementability. • Moderate implementation risk. • Lowest NPV.	3.2

Barrier Wall Configuration	Barrier Wall Technology	Barrier Wall Depth	Effectiveness	Score	Long-Term Reliability	Score	Implementability	Score	Implementation Risk	Score	Reasonableness of Cost	Score	Summary of Evaluation	Average Score
River Side High Bank Route	Slurry Trench Slurry Wall	T.D. to Basalt	Essentially the same comments as for the River Side High Bank Vibrated Beam alternative, except: • Hydraulic conductivity of soil-slurry backfill was slightly less than for clay-cement plastic concrete sample and adequately low to accomplish control of affected groundwater. • Slightly greater volume of potentially affected RA construction residuals.	2.5	Essentially the same comments as for the River Side High Bank Vibrated Beam alternative. • Hydraulic conductivity of soil-slurry backfill was shown to be stable for control of affected ground water based on pore volume of each affected groundwater sample used as permeants, including for sample prepared using DNAPL-affected soil.	3.5	Essentially the same comments as for the River Side High Bank Vibrated Beam alternative except: • More uncertainty related to potential for chloride-affected formation and ground water to affected stability of slurry during slurry trench excavation. • Clearance of subsurface objects > 24-inch maximum dimension. • Uses proven CQA/CQC inspection and testing to measure quality of construction.	3.5	Essentially the same comments as for the River Side High Bank Vibrated Beam alternative except: • More potential for exposure of workers and the environment to COCs excavated from the trench and during slurry backfill mixing. • No significant vibration.	2.5	Essentially the same comments as for the River Side High Bank Vibrated Beam alternative except: • Higher low-range capital cost. • NPV = $9,800,000	2	• Reasonable effectiveness. • Very good reliability. • Very good implementability. • Some implementation risk. • Low-range NPV.	2.8
River Side High Bank Route	Sealed Steel Sheet Pile	T.D. to Basalt	Essentially the same comments as for the River Side High Bank Vibrated Beam alternative, except: • Hydraulic conductivity of sheet pile is zero at sheets and is anticipated to be insignificant at joints sealed with compatible sealant; adequately low to accomplish control of groundwater. • Lower volume of potentially affected RA construction residuals.	3.5	Essentially the same comments as for the River Side High Bank Vibrated Beam alternative.	3.5	Essentially the same comments as for the River Side High Bank Vibrated Beam alternative except: • Smaller debris can obstruct installation. • Subject to corrosion, but not expected to affect useful life of barrier wall. • Uses proven CQA/CQC inspection and testing to measure quality of construction.	3	Essentially the same comments as for the River Side High Bank Vibrated Beam alternative except: • Less potential for exposure of workers and the environments to COCs excavated from the trench and during slurry backfill mixing. • Vibration may be significant off site; needs more study if sheet pile barrier wall is chosen.	3.5	Essentially the same comments as for the River Side High Bank Vibrated Beam alternative except: • High median-range capital cost. • NPV = $15,200,000	1.5	• Very good effectiveness. • Very good reliability. • Good implementability. • Very low implementation risk. • High median-range NPV.	3

Barrier Wall Configuration	Barrier Wall Technology	Barrier Wall Depth	Effectiveness	Score	Long-Term Reliability	Score	Implementability	Score	Implementation Risk	Score	Reasonableness of Cost	Score	Summary of Evaluation	Average Score
Full Enclosure Route	Vibrated Beam Slurry Wall	T.D. to Basalt	Essentially the same comments as for the River Side High Bank Vibrated Beam alternative, except: • Larger amount of RA construction affected residuals.	2.5	Essentially the same comments as for the River Side High Bank Vibrated Beam alternative.	3.5	Essentially the same comments as for the River Side High Bank Vibrated Beam alternative, except: • Greater length presents greater uncertainty. • Uses proven CQA/CQC inspection and testing to measure quality of construction.	3	Essentially the same comments as for the River Side High Bank Vibrated Beam alternative, except: • Slightly more impacts on community. • Slightly more potential for adverse impact on workers. • Slightly more potential for adverse impact on environment.	2.5	• High-range capital cost. • No O&M cost. • No special periodic review needed. • NPV = $17,200,000	2.5	• Moderate effectiveness. • Very good reliability. • Good implementability. • Some implementation risk. • High-range NPV.	2.8
Full Enclosure Route	Slurry Trench Slurry Wall	T.D. to Basalt	Essentially the same comments as for the Full Enclosure Vibrated Beam alternative, except: • Slightly greater volume of potentially affected RA construction residuals.	2	Essentially the same comments as for the Full Enclosure Vibrated Beam alternative.	3.5	Essentially the same comments as for the Full Enclosure Vibrated Beam alternative except: • More uncertainty related to potential for chloride-affected formation and ground water to affect stability of slurry during slurry trench excavation. • Clearance of subsurface objects > 24-inch maximum dimension. • Uses proven CQA/CQC inspection and testing to measure quality of construction.	2.5	Essentially the same comments as for Full Enclosure Vibrated Beam alternative except: • More potential for exposure of workers and the environments to COCs excavated from the trench and during slurry backfill mixing.	2	Essentially the same comments as for Full Enclosure Vibrated Beam alternative except: • Higher high-range capital cost. • NPV = $18,100,000	2	• Poor effectiveness. • Very good reliability. • Moderate implementability. • High implementation risk. • High-range NPV.	2.4

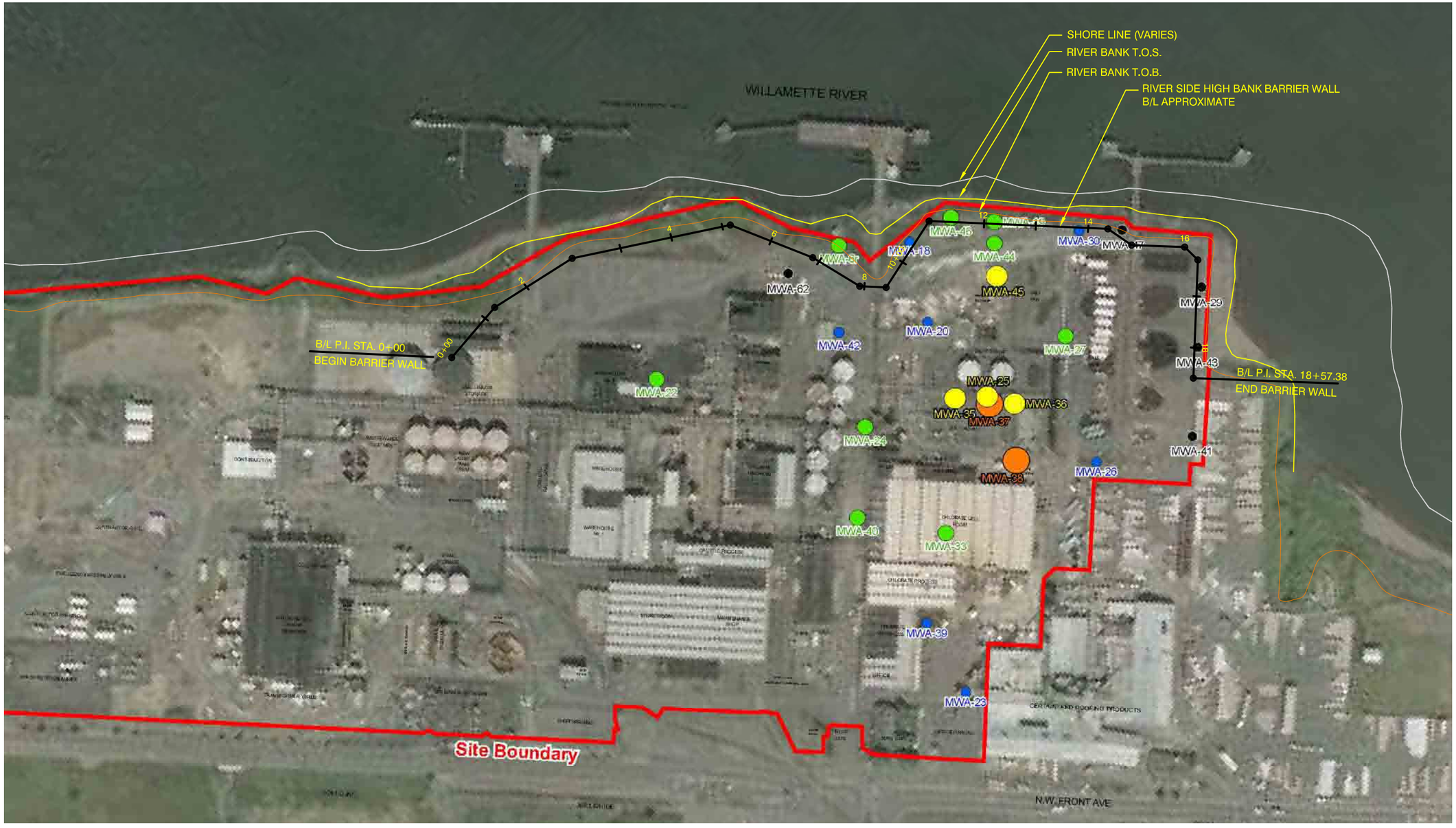
Barrier Wall Configuration	Barrier Wall Technology	Barrier Wall Depth	Effectiveness	Score	Long-Term Reliability	Score	Implementability	Score	Implementation Risk	Score	Reasonableness of Cost	Score	Summary of Evaluation	Average Score
Full Enclosure Route	Sealed Steel Sheet Pile	T.D. to Basalt	Essentially the same comments as for the Full Enclosure Vibrated Beam alternative, except: • Lower volume of potentially affected RA construction residuals.	3	Essentially the same comments as for the Full Enclosure Vibrated Beam alternative.	3.5	Essentially the same comments as for the Full Enclosure Vibrated Beam alternative except: • Smaller debris can obstruct installation. • Subject to corrosion, but not expected to affect useful life of barrier wall. • Uses proven CQA/CQC inspection and testing to measure quality of construction.	2	Essentially the same comments as for the Full Enclosure Vibrated Beam alternative except: • Less potential for exposure of workers and the environments to COCs excavated from the trench and during slurry backfill mixing.	3	Essentially the same comments as for the Full Enclosure Vibrated Beam Deep Zone Key alternative except: • Much higher high-range capital cost. • NPV = $29,800,000	1.5	• Good effectiveness. • Very good reliability. • Poor implementability. • Low implementation risk. • High-range NPV.	2.6

Notes:

1. Each alternative was scored against each criterion on a scale of 1 to 4 (1 = not anticipated to meet evaluation factor, 4 = anticipated to meet evaluation factor)
2. Budgetary costs (+50% to -30%) for each alternative were developed for the Focused Feasibility Study, and are intended for comparison purposes only.

COCs = Constituents of Concern
PPE = Personal Protective Equipment
RA = Remedial Action
T.D. = Total Depth
GWE = Groundwater Extractions
NPV = Net Present Value
O&M = Operation and Maintenance

Attachment A
Figures Depicting Proposed Barrier Wall Location and Groundwater Concentrations of Primary Constituents of Concern



LEGEND

- Barrier Wall
- River Bank T.O.B
- River Bank T.O.S.
- Shore Line

Hexavalent Chromium Concentration (µg/l)

- < 11 (JSCS Screening Criteria = 11 µg/l)
- 11 - 110 (DEQ Screening Criteria = 110 µg/l)
- 110 - 1,000
- 1,000 - 10,000
- > 10,000
- Not detected

ABBREVIATIONS and ACRONYMS

B/L	BASELINE
P.I.	POINT OF INTERSECTION
STA.	STATION (100-FOOT STATION BASIS)
T.O.B	TOP OF BANK
T.O.S	TOP OF SLOPE

0 200
FEET

Figure H-1
Proposed Barrier Wall Location and Hexavalent Chromium Groundwater Concentrations Shallow Aquifer, April 2007
Arkema Inc.
Portland, Oregon

ERM 09/08

Project No. 0065572.01
Date: 09/12/08
Drawn By: J. Estrada
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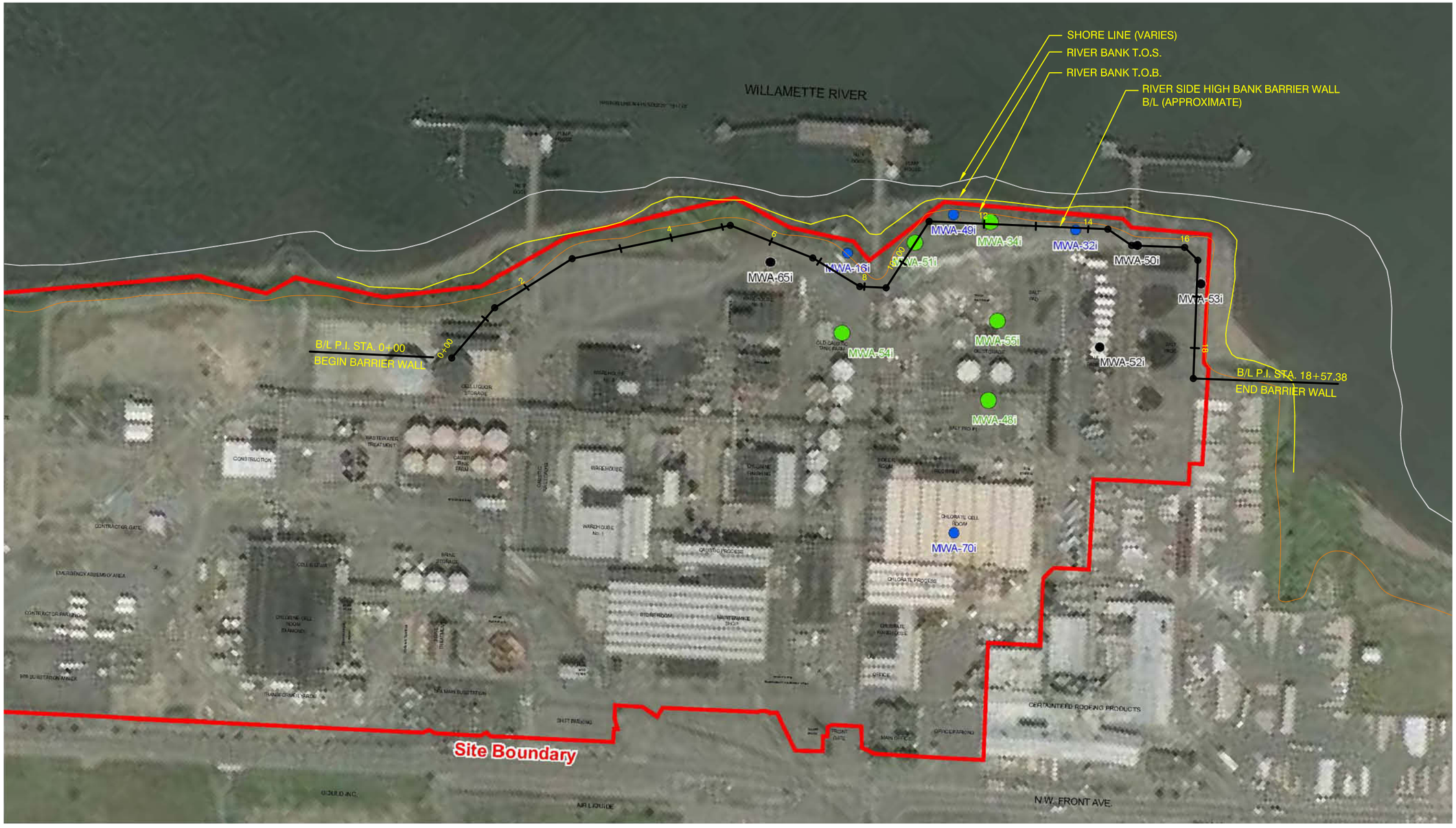

LEGEND

- Barrier Wall
- River Bank T.O.B
- River Bank T.O.S.
- Shore Line

Hexavalent Chromium Concentration (µg/l)

- < 11 (JSCS Screening Criteria = 11 µg/l)
- 11 - 110 (DEQ Screening Criteria = 110 µg/l)
- 110 - 1,000
- 1,000 - 10,000
- > 10,000
- Not detected

ABBREVIATIONS and ACRONYMS

B/L	BASELINE
P.I.	POINT OF INTERSECTION
STA.	STATION (100-FOOT STATION BASIS)
T.O.B	TOP OF BANK
T.O.S	TOP OF SLOPE

0 200
FEET

Figure H-2
Proposed Barrier Wall Location and Hexavalent Chromium Groundwater Concentrations Intermediate Aquifer, April 2007
Arkema Inc.
Portland, Oregon

ERM 09/08

Project No. 0065572.01
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Drawn By: J. Estrada
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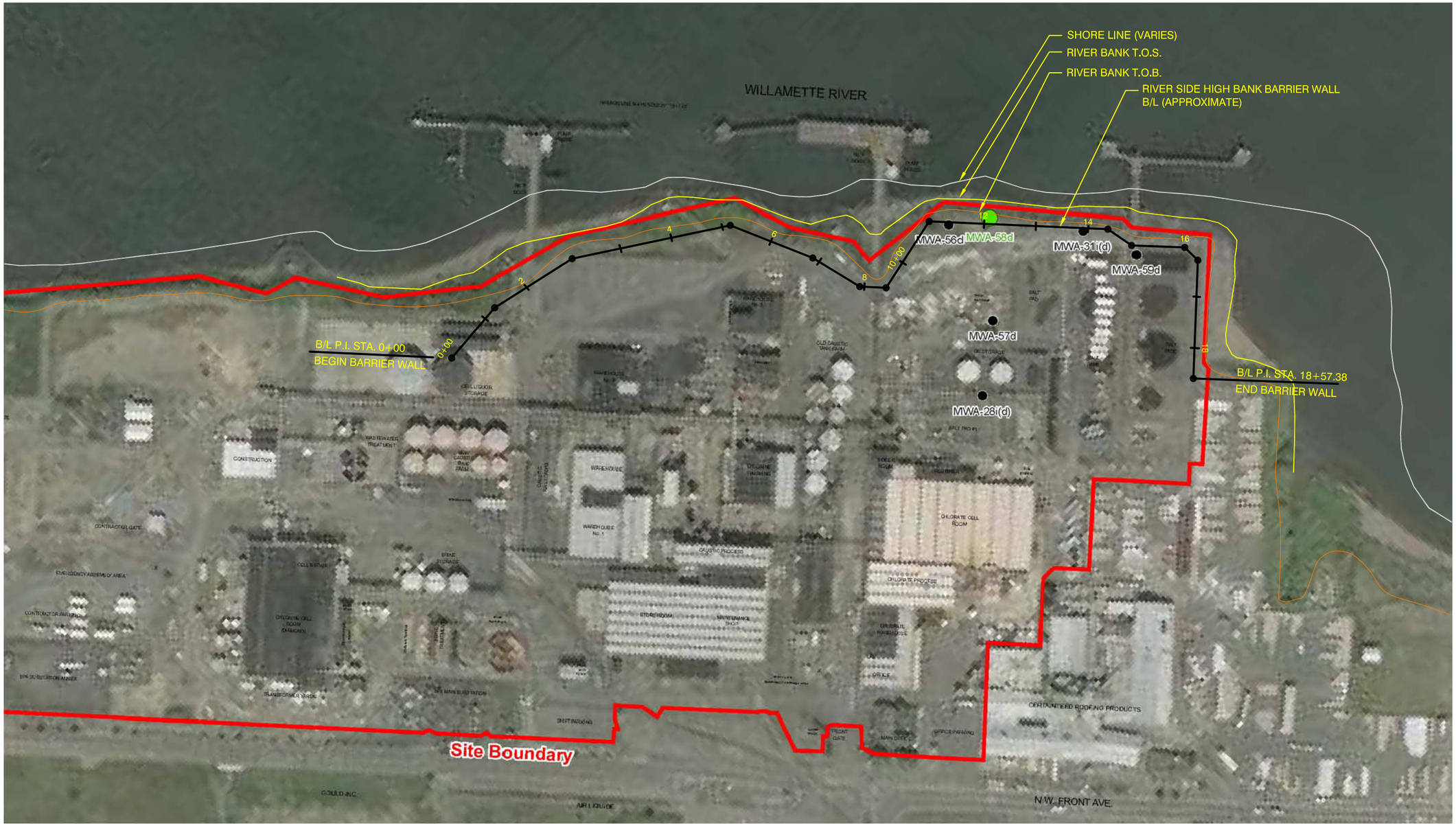

LEGEND

- Barrier Wall
- River Bank T.O.B
- River Bank T.O.S.
- Shore Line

Hexavalent Chromium Concentration (µg/l)

- < 11 (JSCS Screening Criteria = 11 µg/l)
- 11 - 110 (DEQ Screening Criteria = 110 µg/l)
- 110 - 1,000
- 1,000 - 10,000
- > 10,000
- Not detected

ABBREVIATIONS and ACRONYMS

B/L	BASELINE
P.I.	POINT OF INTERSECTION
STA.	STATION (100-FOOT STATION BASIS)
T.O.B	TOP OF BANK
T.O.S	TOP OF SLOPE

0 200
FEET

Figure H-3
Proposed Barrier Wall Location and Hexavalent Chromium Groundwater Concentrations Deep Aquifer, April 2007
Arkema Inc.
Portland, Oregon

ERM 09/08

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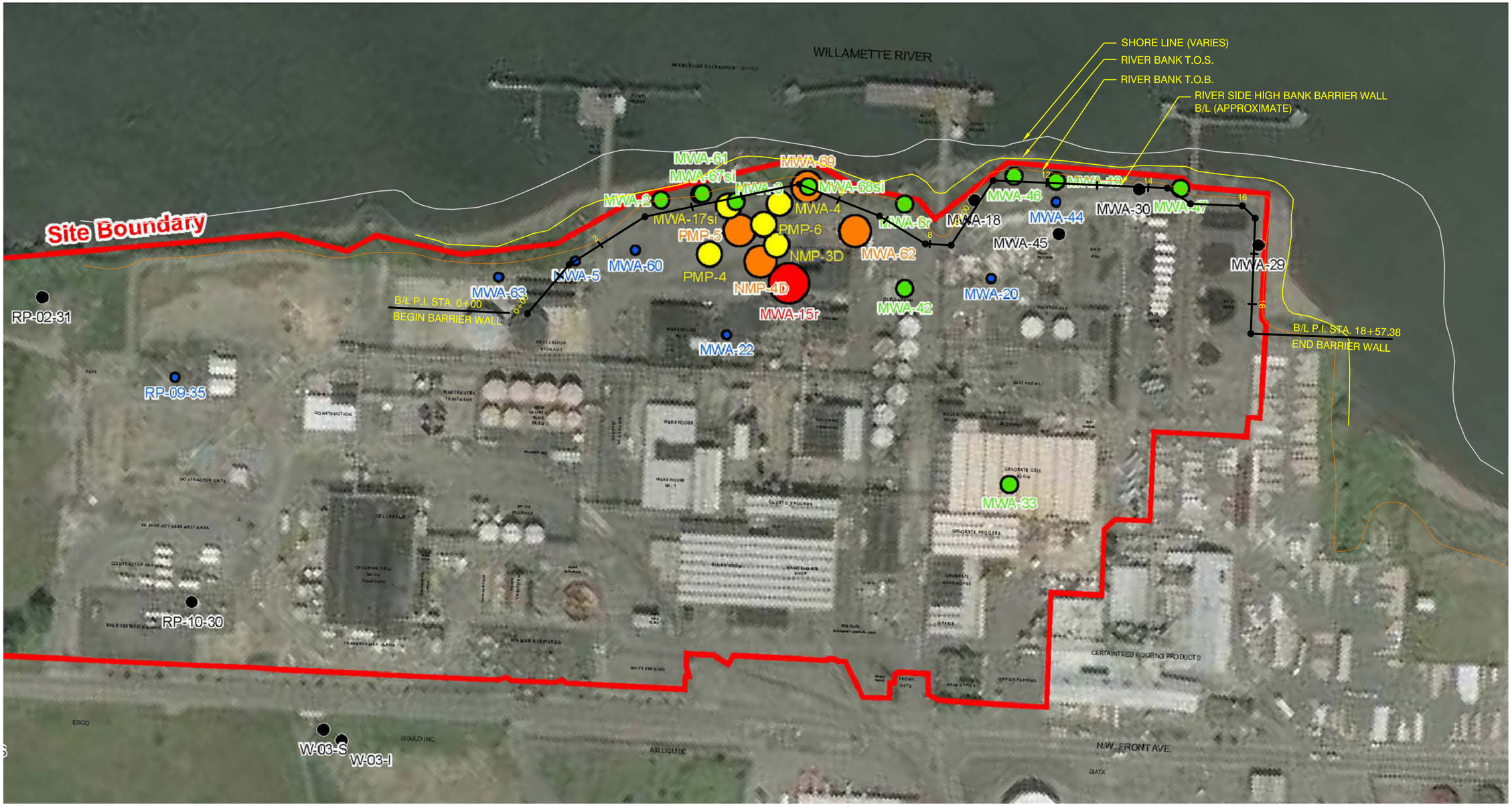


LEGEND

- Barrier Wall
- River Bank T.O.B
- River Bank T.O.S.
- Shore Line

DDx Concentration (µg/l)

- < 0.2 (DEQ Screening Criteria = 0.2 µg/l)
- 0.2 - 1
- 1 - 10
- 10 - 100
- 100 - 1,000
- > 1,000

Note: DDX = Sum total of DDT, DDD, and DDE concentrations.

ABBREVIATIONS and ACRONYMS

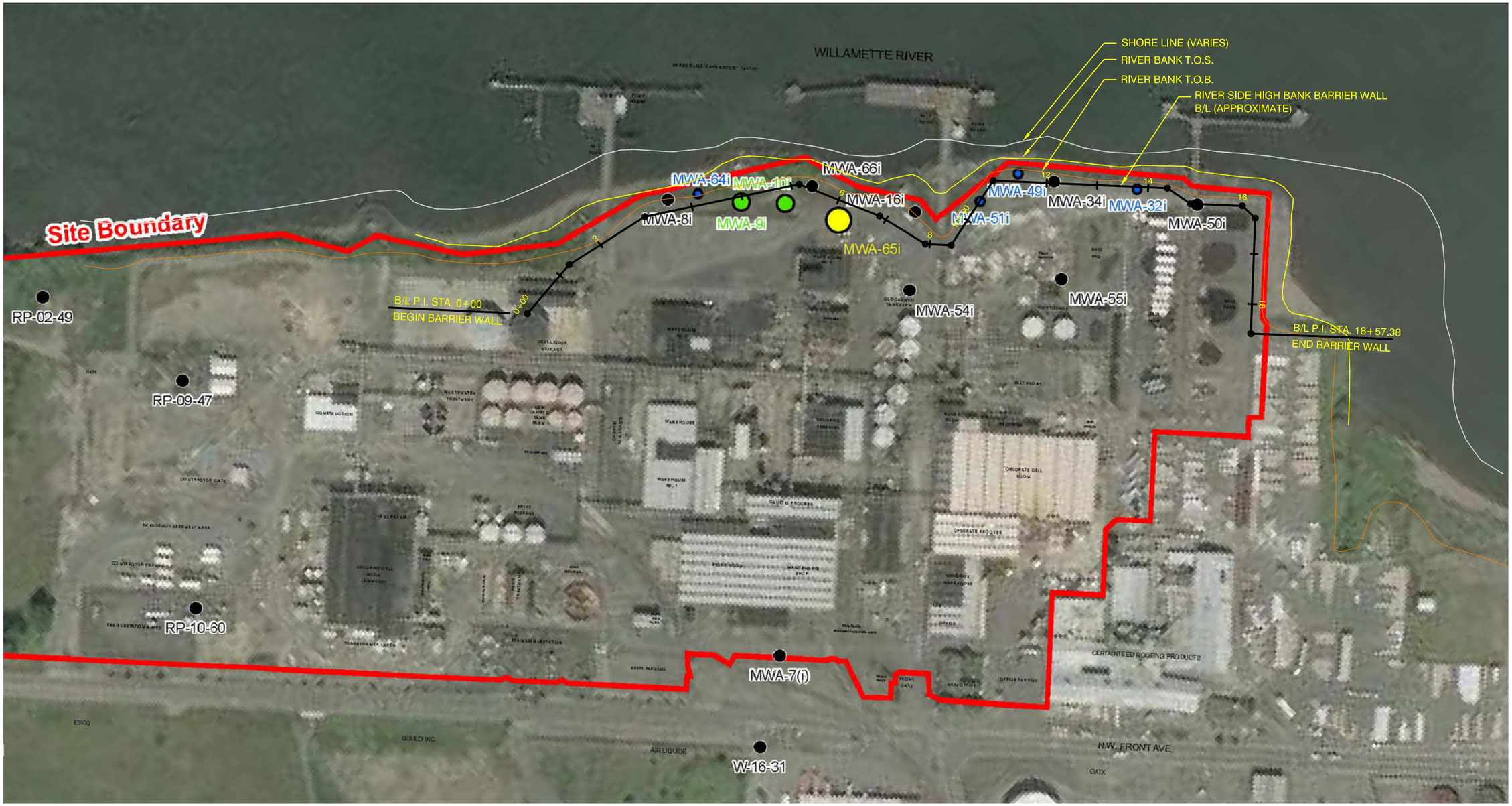
B/L	BASELINE
P.I.	POINT OF INTERSECTION
STA.	STATION (100-FOOT STATION BASIS)
T.O.B	TOP OF BANK
T.O.S	TOP OF SLOPE

Note: All offsite groundwater data was collected during the Spring 2000 groundwater monitoring event (March & April 2000).
Reference: Final Spring and Fall 2000 Groundwater Data and Evaluation RPAC - Portland Site, AMEC Earth & Environmental, July 2001.

0 200
FEET

Figure H-4
Proposed Barrier Wall Location and DDx Groundwater Concentrations Shallow Aquifer, April 2007
Arkema Inc.
Portland, Oregon

ERM 09/08



LEGEND

Barrier Wall
River Bank T.O.B
River Bank T.O.S.
Shore Line

DDx Concentration (µg/l)

- < 0.2 (DEQ Screening Criteria = 0.2 µg/l)
- 0.2 - 1
- 1 - 10
- 10 - 100
- 100 - 1,000
- > 1,000
- Not detected

Note: DDX = Sum total of DDT. DDD. and DDE concentrations.

ABBREVIATIONS and ACRONYMS

B/L	BASELINE
P.I.	POINT OF INTERSECTION
STA.	STATION (100-FOOT STATION BASIS)
T.O.B	TOP OF BANK
T.O.S	TOP OF SLOPE

Note: All offsite groundwater data was collected during the Spring 2000 groundwater monitoring event (March & April 2000).
Reference: Final Spring and Fall 2000 Groundwater Data and Evaluation RPAC - Portland Site, AMEC Earth & Environmental, July 2001.

0 200
FEET

Figure H-5
Proposed Barrier Wall Location and DDx Groundwater Concentrations Intermediate Aquifer, April 2007
Arkema Inc.
Portland, Oregon

ERM *09/08*

Project No. 0065572.01
Date: 09/12/08
Drawn By: J. Estrada
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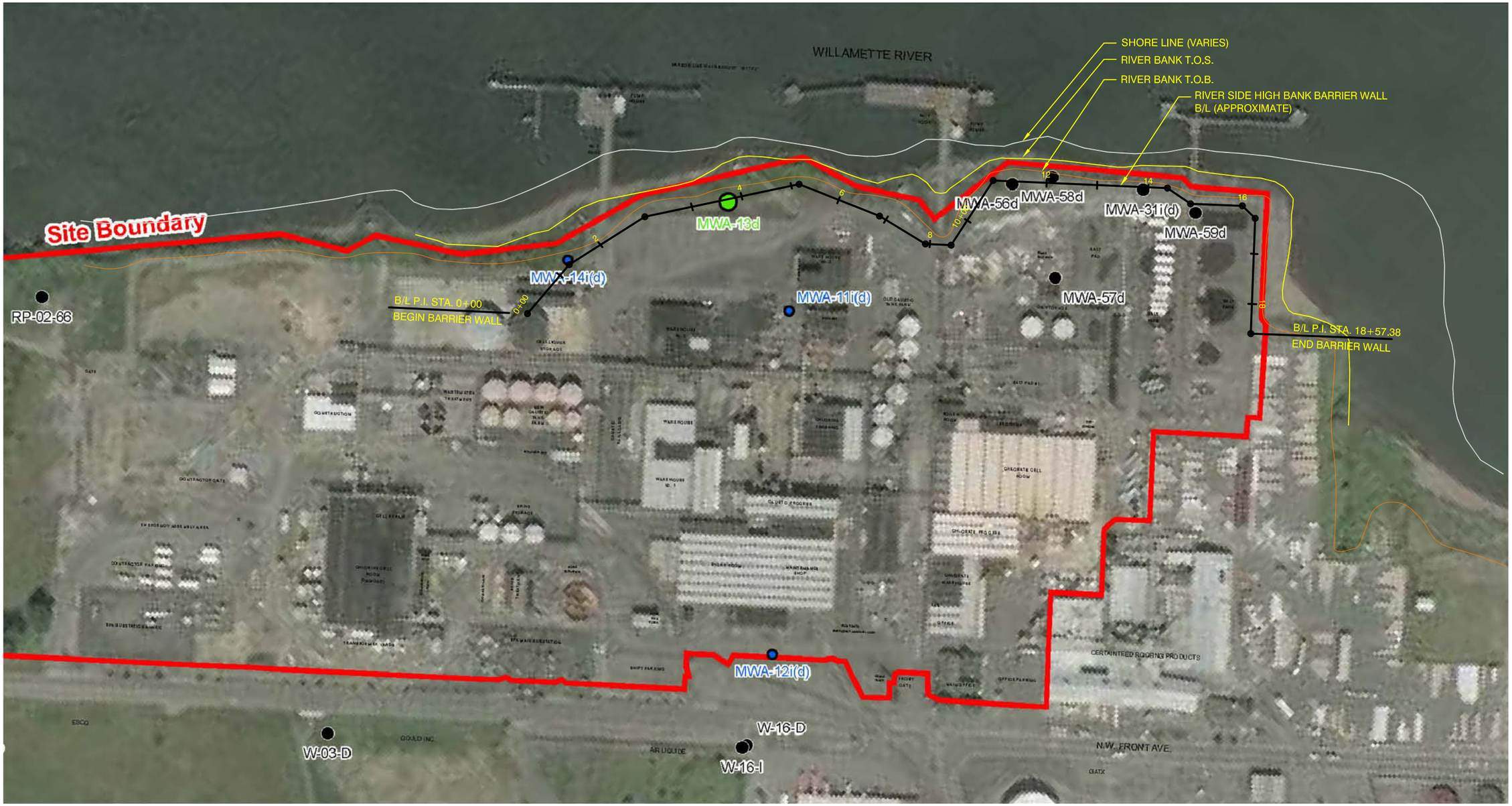


LEGEND

Barrier Wall
River Bank T.O.B
River Bank T.O.S.
Shore Line

DDx Concentration (µg/l)

- < 0.2 (DEQ Screening Criteria = 0.2 µg/l)
- 0.2 - 1
- 1 - 10
- 10 - 100
- 100 - 1,000
- > 1,000
- Not detected

Note: DDX = Sum total of DDT. DDD. and DDE concentrations.

ABBREVIATIONS and ACRONYMS

B/L	BASELINE
P.I.	POINT OF INTERSECTION
STA.	STATION (100-FOOT STATION BASIS)
T.O.B	TOP OF BANK
T.O.S	TOP OF SLOPE

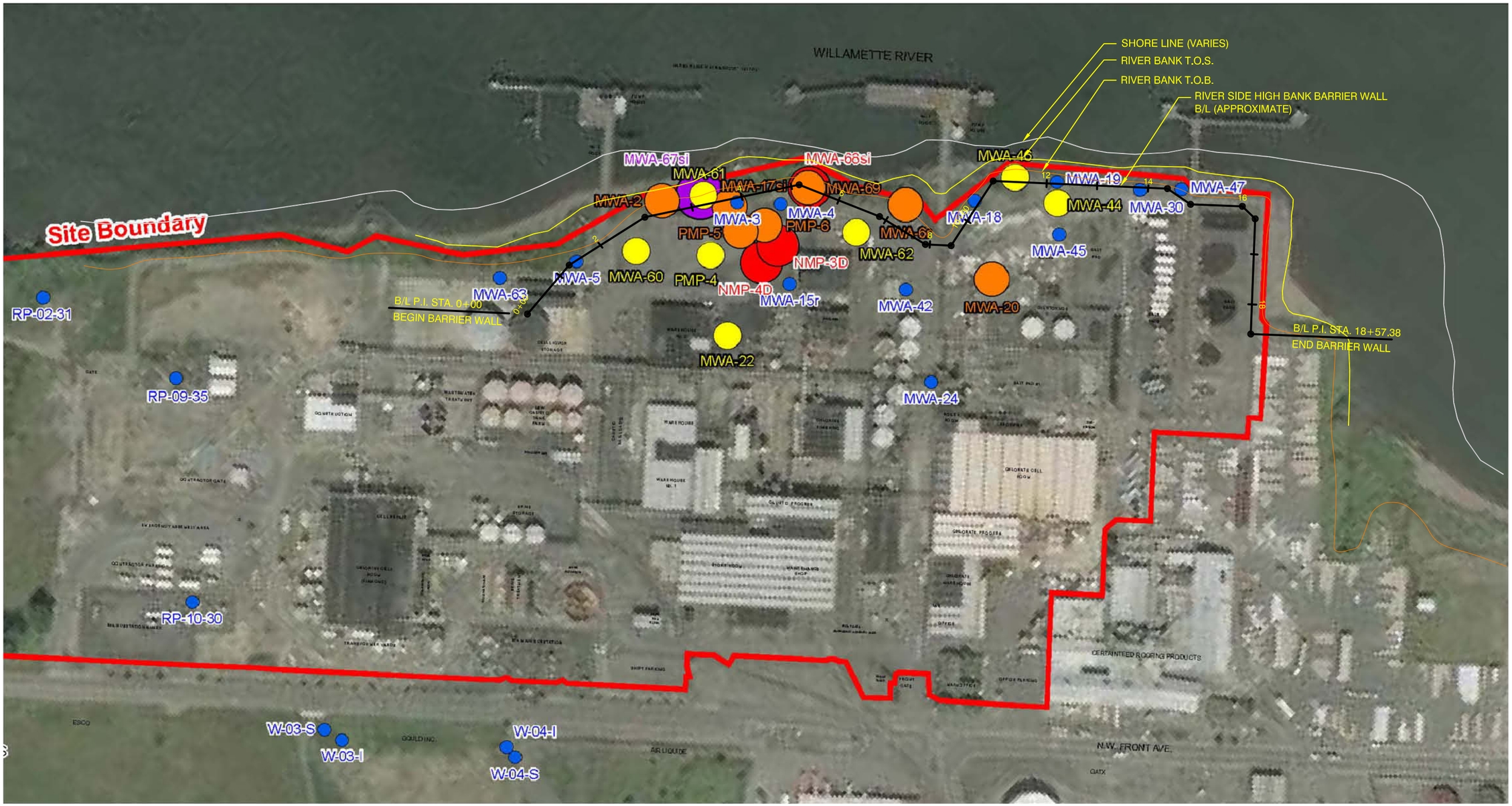
Note: All offsite groundwater data was collected during the Spring 2000 groundwater monitoring event (March & April 2000).
Reference: Final Spring and Fall 2000 Groundwater Data and Evaluation RPAC - Portland Site, AMEC Earth & Environmental, July 2001.

0 200
FEET

Figure H-6
Proposed Barrier Wall Location and DDx Groundwater Concentrations Deep Aquifer, April 2007
Arkema Inc.
Portland, Oregon

ERM *09/08*

Project No. 0065572.01
Date: 09/12/08
Drawn By: J. Estrada
CAD File: g:\\0065572\01\006557201-07.dwg



LEGEND

- Barrier Wall
- River Bank T.O.B
- River Bank T.O.S.
- Shore Line

Chlorobenzene Concentration (µg/l)

- < 50 (JSCS Screening Criteria = 50 µg/l)
- 50 - 100 (DEQ Screening Criteria = 100 µg/l)
- 100 - 1,000
- 1,000 - 10,000
- 10,000 - 100,000
- > 100,000
- Not detected

ABBREVIATIONS and ACRONYMS

B/L	BASELINE
P.I.	POINT OF INTERSECTION
STA.	STATION (100-FOOT STATION BASIS)
T.O.B	TOP OF BANK
T.O.S	TOP OF SLOPE

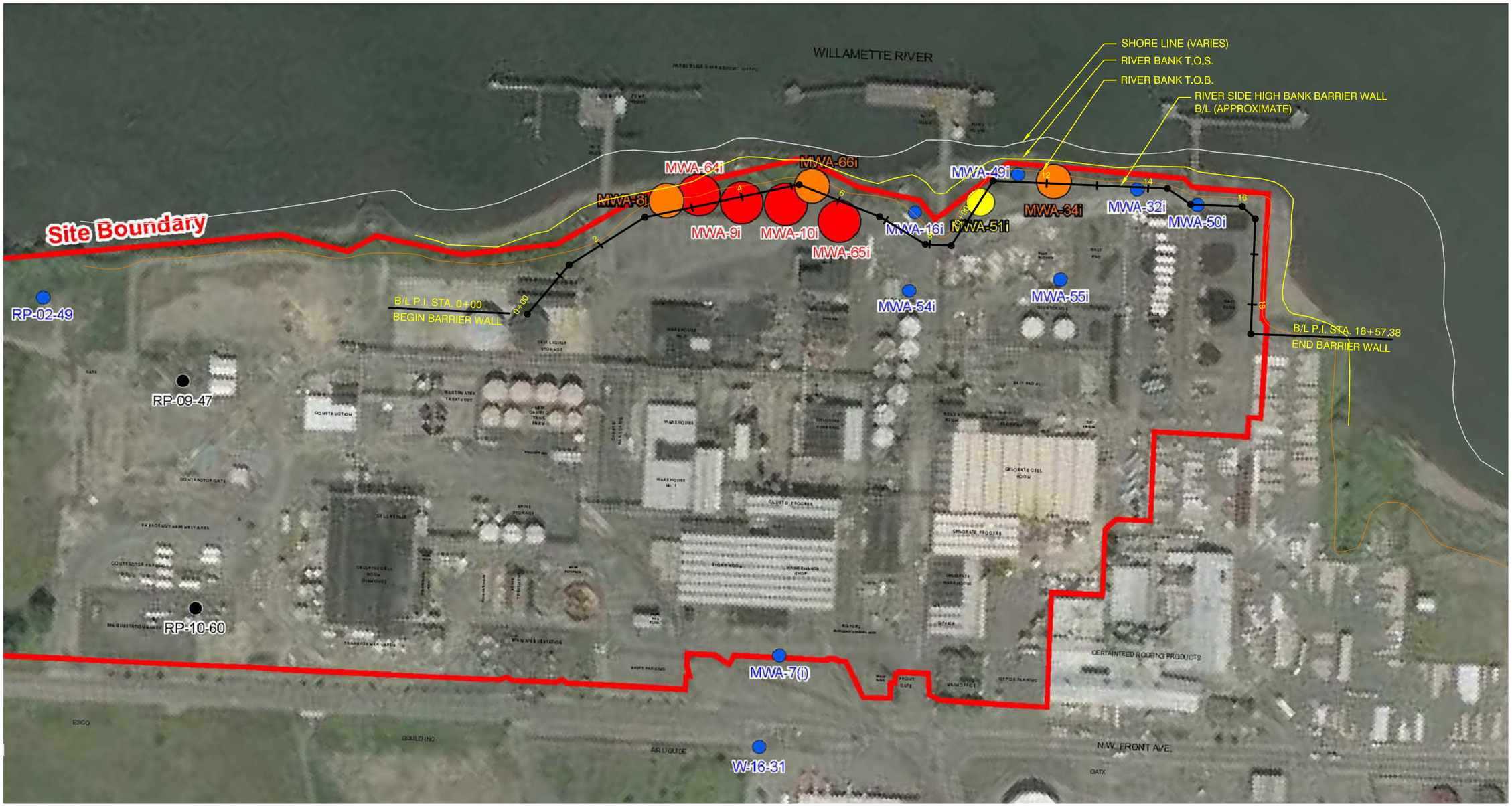
Note: All offsite groundwater data was collected during the Spring 2000 groundwater monitoring event (March & April 2000).
Reference: Final Spring and Fall 2000 Groundwater Data and Evaluation RPAC - Portland Site, AMEC Earth & Environmental, July 2001.

0 200
FEET

Figure H-7
Proposed Barrier Wall Location and Chlorobenzene Groundwater Concentrations Shallow Aquifer, April 2007
Arkema Inc.
Portland, Oregon

ERM 09/08

CAD File: g:_0065572\01_006557201-08.dwg
Drawn By: J. Estrada
Date: 09/12/08
Project No. 0065572.01



LEGEND

- Barrier Wall
- River Bank T.O.B
- River Bank T.O.S.
- Shore Line

Chlorobenzene Concentration (µg/l)

- < 50 (JSCS Screening Criteria = 50 µg/l)
- 50 - 100 (DEQ Screening Criteria = 100 µg/l)
- 100 - 1,000
- 1,000 - 10,000
- 10,000 - 100,000
- > 100,000
- Not detected

ABBREVIATIONS and ACRONYMS

B/L	BASELINE
P.I.	POINT OF INTERSECTION
STA.	STATION (100-FOOT STATION BASIS)
T.O.B	TOP OF BANK
T.O.S	TOP OF SLOPE

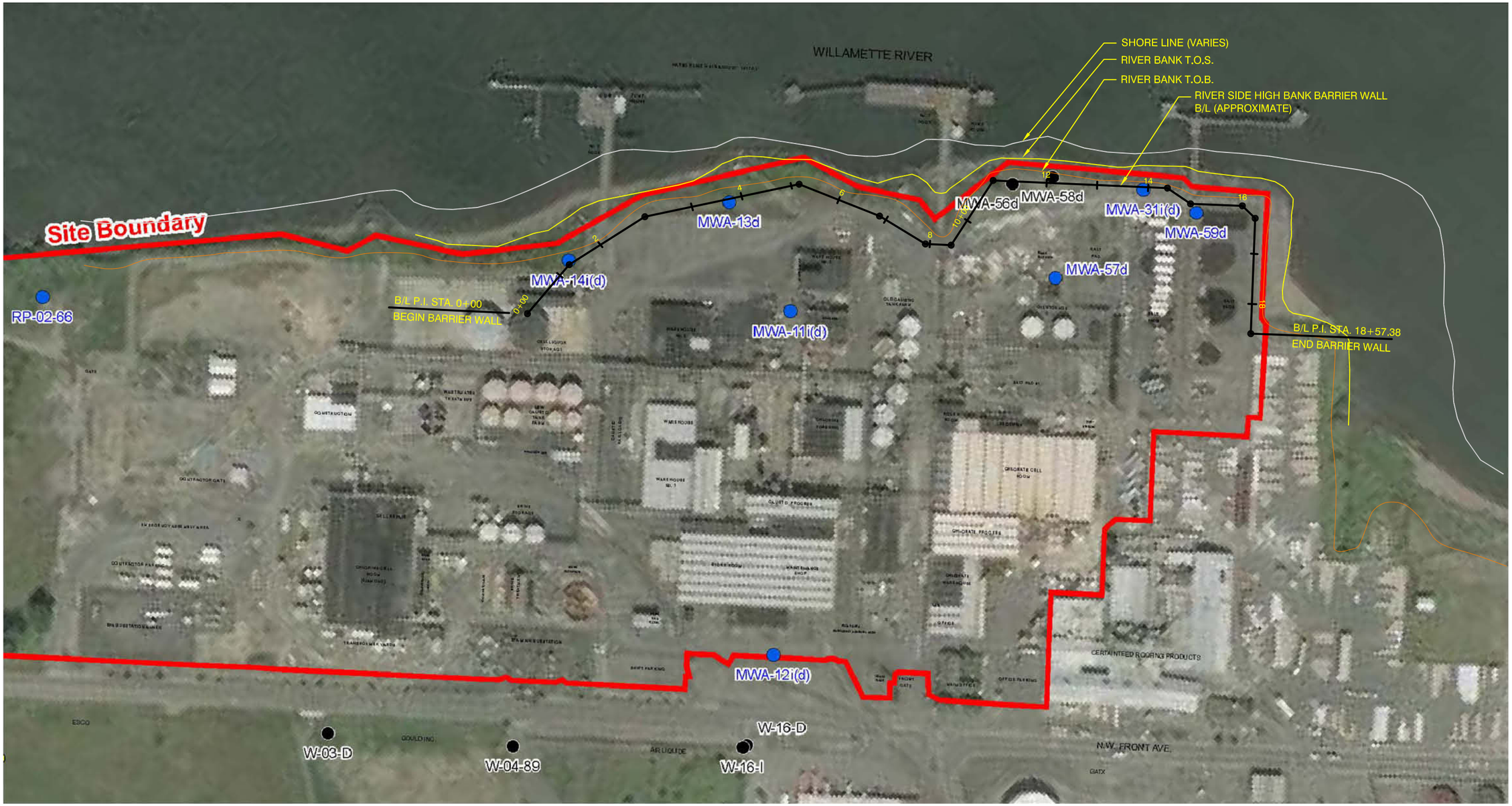
Note: All offsite groundwater data was collected during the Spring 2000 groundwater monitoring event (March & April 2000).
Reference: Final Spring and Fall 2000 Groundwater Data and Evaluation RPAC - Portland Site, AMEC Earth & Environmental, July 2001.

0 200
FEET

Figure H-8
Proposed Barrier Wall Location and Chlorobenzene Groundwater Concentrations Intermediate Aquifer, April 2007
Arkema Inc.
Portland, Oregon

ERM 09/08

Project No. 0065572.01
Date: 09/12/08
Drawn By: J. Estrada
CAD File: g:\\0065572\01\006557201-09.dwg



LEGEND

- Barrier Wall
- River Bank T.O.B
- River Bank T.O.S.
- Shore Line

Chlorobenzene Concentration (µg/l)

- < 50 (JSCS Screening Criteria = 50 µg/l)
- 50 - 100 (DEQ Screening Criteria = 100 µg/l)
- 100 - 1,000
- 1,000 - 10,000
- 10,000 - 100,000
- > 100,000
- Not detected

ABBREVIATIONS and ACRONYMS

B/L	BASELINE
P.I.	POINT OF INTERSECTION
STA.	STATION (100-FOOT STATION BASIS)
T.O.B	TOP OF BANK
T.O.S	TOP OF SLOPE

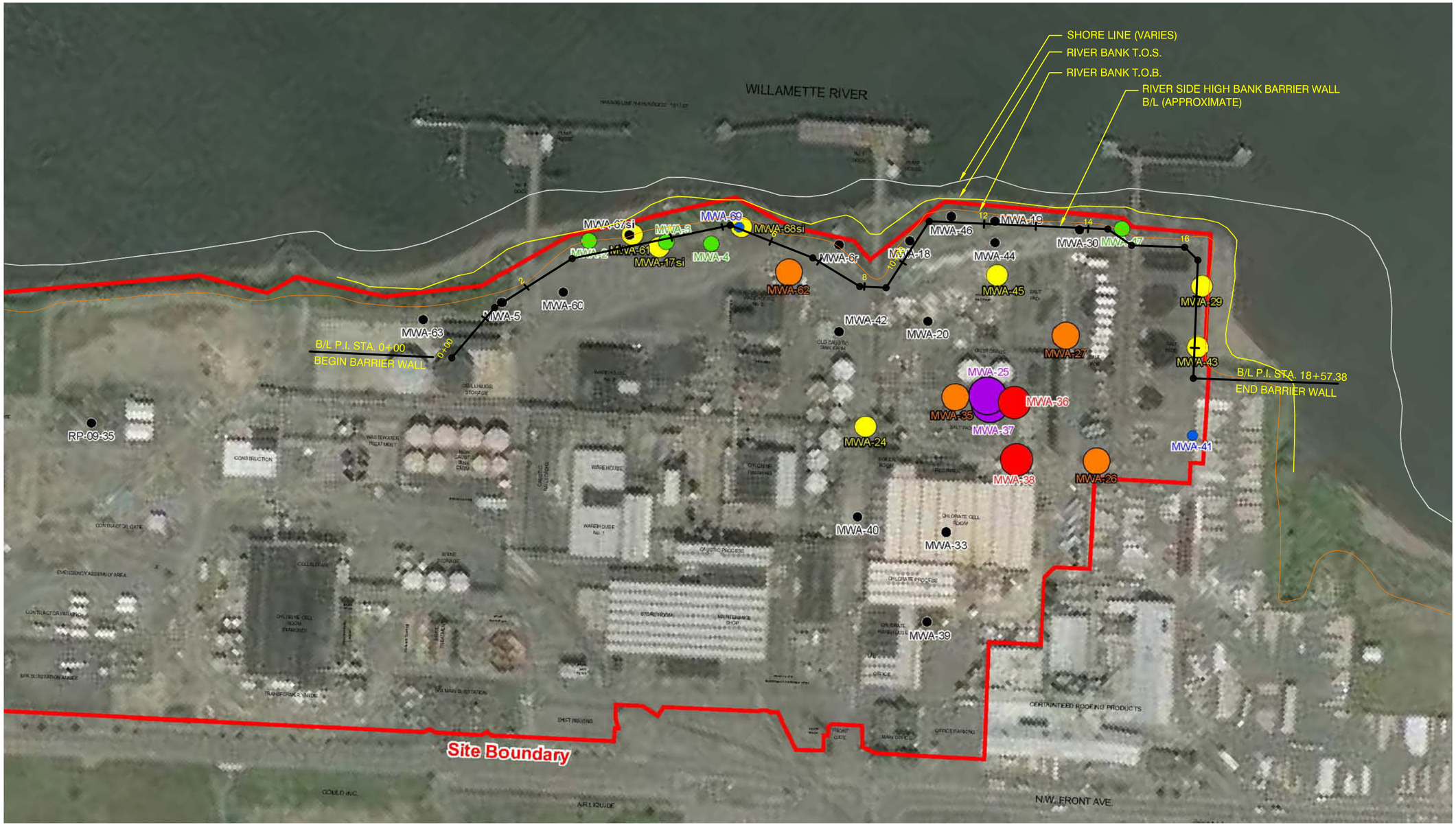
Note: All offsite groundwater data was collected during the Spring 2000 groundwater monitoring event (March & April 2000).
Reference: Final Spring and Fall 2000 Groundwater Data and Evaluation RPAC - Portland Site, AMEC Earth & Environmental, July 2001.

0 200
FEET

Figure H-9
Proposed Barrier Wall Location and Chlorobenzene Groundwater Concentrations Deep Aquifer, April 2007
Arkema Inc.
Portland, Oregon

ERM 09/08

CAD File: g:\\0065572\01\006557201-10.dwg
Drawn By: J. Estrada
Date: 09/12/08
Project No. 0065572.01



LEGEND

- Barrier Wall
- River Bank T.O.B
- River Bank T.O.S.
- Shore Line

Perchlorate Concentration (µg/l)

- < 36 (JSCS Screening Criteria = 36 µg/l) (DEQ Screening Criteria = 24.5 µg/l)
- 36 - 100
- 100 - 1,000
- 1,000 - 10,000
- 10,000 - 100,000
- > 100,000
- Not detected

ABBREVIATIONS and ACRONYMS

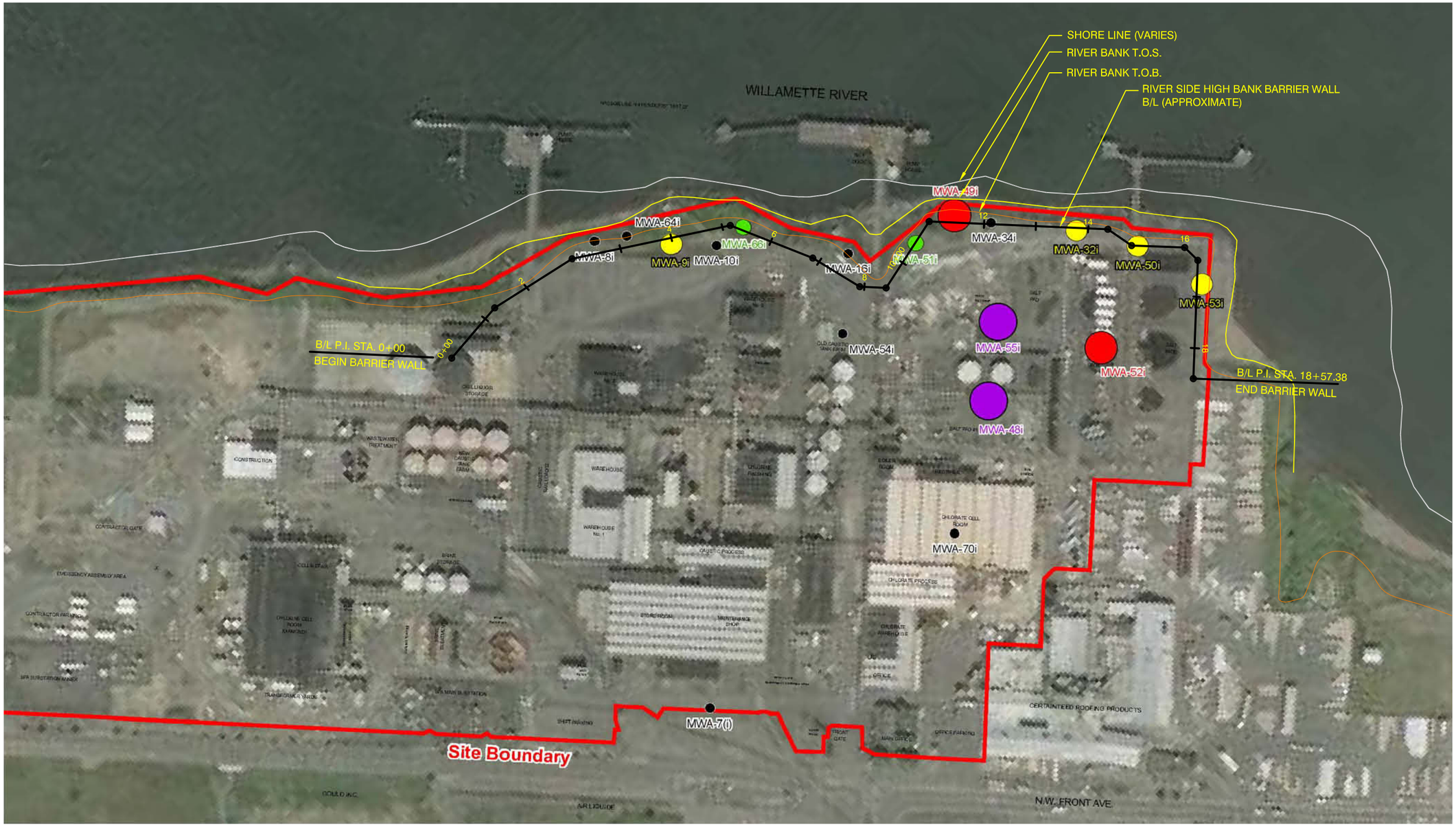
B/L	BASELINE
P.I.	POINT OF INTERSECTION
STA.	STATION (100-FOOT STATION BASIS)
T.O.B	TOP OF BANK
T.O.S	TOP OF SLOPE

0 200
FEET

Figure H-10
Proposed Barrier Wall Location and Perchlorate Groundwater Concentrations Shallow Aquifer, April 2007
Arkema Inc.
Portland, Oregon

ERM 09/08

Project No. 0065572.01
Date: 09/12/08
Drawn By: J. Estrada
CAD File: g:\0065572\01\006557201-11.dwg



LEGEND

- Barrier Wall
- River Bank T.O.B
- River Bank T.O.S.
- Shore Line

Perchlorate Concentration (µg/l)

- < 36 (JSCS Screening Criteria = 36 µg/l) (DEQ Screening Criteria = 24.5 µg/l)
- 36 - 100
- 100 - 1,000
- 1,000 - 10,000
- 10,000 - 100,000
- > 100,000
- Not detected

ABBREVIATIONS and ACRONYMS

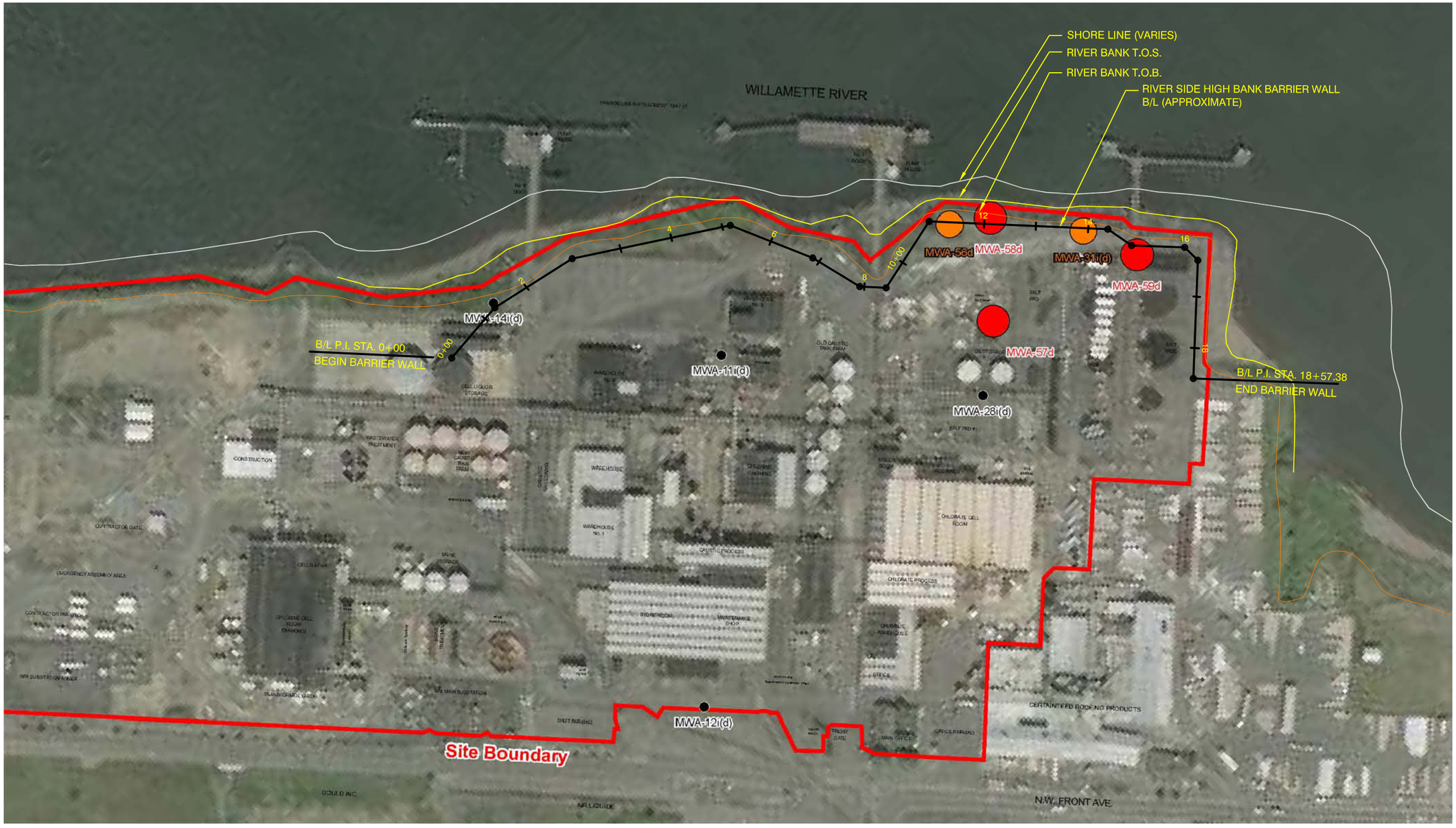
B/L	BASELINE
P.I.	POINT OF INTERSECTION
STA.	STATION (100-FOOT STATION BASIS)
T.O.B	TOP OF BANK
T.O.S	TOP OF SLOPE

0 200
FEET

Figure H-11
Proposed Barrier Wall Location and Perchlorate Groundwater Concentrations Intermediate Aquifer, April 2007
Arkema Inc.
Portland, Oregon

ERM 09/08

Project No. 0065572.01
Date: 09/12/08
Drawn By: J. Estrada
CAD File: g:\\0065572\01\0065572 01-12.dwg



LEGEND

Barrier Wall
River Bank T.O.B
River Bank T.O.S.
Shore Line

Perchlorate Concentration (µg/l)

< 36 (JSCS Screening Criteria = 36 µg/l)
(DEQ Screening Criteria = 24.5 µg/l)
36 - 100
100 - 1,000
1,000 - 10,000
10,000 - 100,000
> 100,000
Not detected

ABBREVIATIONS and ACRONYMS

B/L	BASELINE
P.I.	POINT OF INTERSECTION
STA.	STATION (100-FOOT STATION BASIS)
T.O.B	TOP OF BANK
T.O.S	TOP OF SLOPE

0 200
FEET

Figure H-12
Proposed Barrier Wall Location and Perchlorate Groundwater Concentrations Deep Aquifer, April 2007
Arkema Inc.
Portland, Oregon

ERM 09/08

Project No. 0065572.01
Date: 09/12/08
Drawn By: J. Estrada
CAD File: g:\\0065572\01\0065572\01\0065572\01-13.dwg

Attachment B
Summary of Previous Vibrated Beam Projects

Slurry Systems INC.

ENVIRONMENTAL WORK & CONTACT INFORMATION:

•SLURRY WALLS,
•PERVIOUS IRON SAND WALLS,
•WATERLOO® SHEET PILE INSTALLATIONS, AND
•GATE & FUNNELS

NOTE:Asterisk (*) indicates Army Corps of Engineers involved in project. Projects in **bold** are projects constructed using the vibrated beam.

DATES	*LOCATION*	*TYPE OF WORK & VALUE (value listed only for vibrated beam projects completed in last 5 years)*	*SLURRY MIX*	*LINEAR FT.*	*DEPTH*	*SQUARE FT.*	*REFERENCES*
*02//06 – Present	MCCOOK RESERVOIR, IL Phase 2	CONVENTIONAL WALL: DEWATERING $ 11,700,000	SOIL BENTONITE	7,450 LF	35' to 60'	335,250 - slurry wall 29,800 - BC40 trench cutter	Nicholas Karnezis Army Corps of Engineers 312-860-0167
03/12/07 – 03/31/07	**PALO ALTO, CA**	**VIBRATED BEAM: CONTAINMENT** **$ 340,500**	**IMPERMIX**	**370'**	**55'**	**20,350**	**Andy Cox Geomatrix 510-663-4164**
10/17/06 – 10/25/06	**WYANDOTTE, MI ARKEMA**	**VIBRATED BEAM: CONTAINMENT** **$ 163,000**	**IMPERMIX**	**712'**	**18'**	**12,770**	**Michael Pinto Legacy Site Services 610-594-4435**
05/15/06 – 06/05/06	**ZIONSVILLE, IN ENVIRO-CHEM**	**VIBRATED BEAM: CONTAINMENT** **$ 245,000**	**IMPERMIX**	**1,100'**	**20'**	**22,000**	**Scott Hayter Environ 847-444-9200**
04/18/05 - 09/09/05	BELVIDERE, IL FORMER MGP SITE	INSTALL WATERLOO® GROUT WATERLOO® $ 804,000	CEMENTITIOUS	311'	41' - 45'	14,000	Daryl Streed Environmental Contractors of Illinois 815-654-4726
01/24/05 - 02/01/05	**BRUNSWICK, ME WAL MART EXPANSION**	**VIBRATED BEAM: DETENTION BASIN $ 152,000**	**CEMENT BENTONITE**	**540'**	**25'**	**13,500**	**Bryan Bailey Alvin J. Coleman & Son, Inc. 603-447-5936**
11/06/04 - 11/20/04	**VICKSBURG, MS INTERNATIONAL PAPER**	**VIBRATED BEAM: CONTAINMENT $ 233,300**	**CEMENT BENTONITE**	**1,500'**	**27'**	**40,500**	**Michael Stuart International Paper 601-631-8213** **Gene Wardlaw GeoScience Eng'rs 601-956-0851**
09/20/04 - 10/05/04	**BLOOMINGTON, IL NICOR GAS**	**VIBRATED BEAM: CONTAINMENT $ 270,000**	**IMPERMIX**	**800'**	**15'**	**12,000**	**Joe Chittet Burns & McDonnell 630-724-3200**
05/22/04 – 06/17/04	**LOCKHART, AL FORMER WOOD PRESERVING SITE**	**VIBRATED BEAM: CONTAINMENT $ 420,000**	**IMPERMIX**	**1,400'**	**42'**	**58,000**	**Herbert Davidson URS 412-503-4700 John O'Brien URS 404-888-8800**
01/26/04 –	**LEE'S SUMMIT, MO**	**VIBRATED BEAM:**					**Tim Adams**

03/02/04	LUCENT TECHNOLOGIES	FUNNEL MANDREL BEAM: GATE $ 300,000	CEMENT BENTONITE PURE IRON SAND	430', 228' 300'	28', 28' 25'	18,424 7,500	ENSR 630-839-5363
*09/22/03 – 01/23/04	SEATTLE, WAPHILIP SERVICES CO.	VIBRATED BEAM: CONTAINMENT $1,340,000	IMPERMIX	1,600'	75'	125,000	Gary Dupuy Geomatrix 206-342-1760 Daniel Hawk URS 206-438-2144
*01/06/03 – 04/11/03	SEATTLE, WA RHONE POULENC SITEREMEDIATION	VIBRATED BEAM: CONTAINMENT $1,420,000	IMPERMIX	2,500'	65'	159,000	Pete Wold Parsons 253-863-5200 Daniel Hawk URS 206-438-2144
09/09/02 – 09/25/02	BLOOMINGTON, IL NICOR GAS FORMER MGP SITE	VIBRATED BEAM: CONTAINMENT $347,000	IMPERMIX	1,700'	26.5'	45,000	Joseph Chittet Burns & McDonnell 630-724-3200
06/12/02 – 06/26/02	HAMMOND, IN HOWARD STREET PUMPING STATION	VIBRATED BEAM: DEWATERING $ 152,000	Cement Bentonite	607'	35'	21,245	Chuck Atkins Hasse Construction 219-932-1611
09/10/01 - 09/25/01	PORT NECHES, TX HUNTSMAN PETROCHEMICAL	VIBRATED BEAM: CONTAINMENT $ 275,000	IMPERMIX	1,740	14'	24,000	Dustin Anderson James Industrial Constructors 337-625-2616
06/28/01 - 08/27/01	GARY, IN GARY STADIUM	VIBRATED BEAM: DEWATERING $ 1.1 M	Cement Bentonite	2,000'	+50'	100,000	Chris Reynolds Rieth Riley 219-977-0722
03/05/01 - 03/07/01	SOUTH BEND, IN GRAND TRUNK RAILROAD	INSTALL WATERLOO® GROUT WATERLOO®	CEMENTITIOUS	50'	23'	1,150	Shea Miller Earth Tech 616-975-4627
01/05/01 - 01/17/01	RIVER FOREST, IL CONCORDIA UNIVERSITY	VIBRATED BEAM: DEWATERING $ 150,000	Cement Bentonite	836'	30'	25,080	Carl Bechtoldt Ragnar Benson 708-488-4130
11/08/00 - 11/17/00	TERRE HAUTE, IN CANADIAN PACIFIC RAIL	INSTALL WATERLOO® GROUT WATERLOO®	CEMENTITIOUS	120'	25'	3,000	Stephen Hill Canadian Pacific Railway 612-347-8120
*04/26/00 – 04/15/03	MCCOOK RESERVOIR, IL Phase 1	CONVENTIONAL WALL: DEWATERING $ 10,900,000	SOIL BENTONITE	7,445 LF	35' to 60'	176,400 - slurry wall 159,400 - chiseling	Richard Hurt Army Corps of Engineers 708-482-4380
*05/08/00 - 06/02/00 - Phase 1 * 07/31/00 - 08/15/00 Phase 2	FORT FAIRFIELD, ME	VIBRATED BEAM: CONTAINMENT $ 440,000	IMPERMIX	1800'	22'	40,000	Garold Fongemie Ed Pelletier & Sons 207-728-3802
12/31/99 - 03/15/00	MILWAUKEE, WI	INSPECT WATERLOO® GROUT WATERLOO®	CEMENTITIOUS	1,890'	16'	30,240	Dan Myers Roy F. Weston 414-354-2977
09/99 - 10/99	SALFORD LANDFILL - COUNTY OF OXFORD - CANADA	VIBRATED BEAM: CONTAINMENT $ 200,000	IMPERMIX	2,430'	35'	85,050	Basil Gallant Berminghammer 905-528-7924
06/99 -	COUNTY OF DUPAGE -	VIBRATED BEAM:	Cement Bentonite	3,520'	50'	176,000	Marcin

10/99	**ITASCA, IL**	**RETENTION POND** **$ 985,000**					**Patrick Engineering** **630-795-7200**
***11/98**	**MARINETTE, WI**	**VIBRATED BEAM: CONTAINMENT** **$ 655,000**	**IMPERMIX**	**700'**	**40'**	**28,000**	**Jeff Danko** **URS** **414-831-4100**
09/98	TOTAL PETROLEUM - ARKANSAS CITY, KS	GROUT WATERLOO®	CEMENTITIOUS	400'	30'	n/a	David Kistler, Jr. K&R Builders 800-972-9850
09/98	**U.S.S. LEAD - EAST CHICAGO, IN**	**VIBRATED BEAM: CONTAINMENT** **$ 600,000**	**IMPERMIX**	**3125'**	**34'**	**106,250**	**Scott Chafin** **ENTACT** **630-616-2100**
07/98	**MARZONE SUPERFUND SITE - TIFTON, GA**	**VIBRATED BEAM: CONTAINMENT** **$ 120,000**	**IMPERMIX**	**420'**	**20'**	**8,400**	**John Custance** **CH2M Hill** **704-329-0073, ext. 222**
10/97	BETA STEEL - PORTAGE, IN	INSTALL WATERLOO® GROUT WATERLOO®	CEMENTITIOUS	500'	45'	22,500	Mike Bailey Tonn & Blank 219-879-7321
10/97	CAPE CANAVERAL, FL	PERVIOUS REACTIVE WALL	IRON SAND	70'	45'	3,150	Kathleen McNelis Earth Tech 864-234-8910
06/97	**CENTRALIA, IL**	**VIBRATED BEAM: CONTAINMENT OF PLUME (OLD GASOLINE STATION)** **$ 100,000**	**IMPERMIX**	**226'**	**18.5'**	**4,181**	**Craig Gocker** **Environmental Management & Technologies** 309-454-1717
05/97	**FREWSBURG, NY**	**VIBRATED BEAM: CONTAINMENT OF DNAPL** **$ 275,000**	**IMPERMIX**	**556'**	**22'**	**12,232**	**Todd Walles** **Roy F. Weston** **414-354-2977**
2/97	**ONSLOW COUNTY, NORTH CAROLINA**	**VIBRATED BEAM: CONTAINMENT FOR PIG LEACHATE** **$ 400,000**	**IMPERMIX**	**2335'**	**23'**	**53,700**	**available upon request**
12/96	**UTICA, IL**	**VIBRATED BEAM: CONTAINMENT FOR HIGH pH LEACHATE**	**IMPERMIX**	**470'**	**18'**	**8,460**	**Kathy Brady** **PQ Corporation** **815-667-4241**
12/96	**BALTIMORE, MD**	**VIBRATED BEAM: TOXIC WASTE CONTROL**	**IMPERMIX**	**3400'**	**28'**	**95,000**	**Mike Casper** **August Mack** **317-579-7400**
11/96	**MUSEUM OF SCIENCE & INDUSTRY**	**VIBRATED BEAM: DEWATERING**	**CEMENT BENTONITE**	**640'**	**23'**	**14,720**	**Ed Jacobsen** **CASE Foundation** **630-529-2911**
9/96	**MORNINGSIDE-SCARBOROUGH, CANADA**	**VIBRATED BEAM: TOXIC WASTE CONTROL**	**CEMENT BENTONITE**	**2300'**	**30'**	**45,500**	**Basil Gallant** **Berminghammer** **905-528-7924**
4/96	MOFFETT AIRFIELD, CA	GATE & FUNNEL	SHEET PILE	70'	25'	1,750	Tim Mower Tetra Tech 303-295-1101
2/96	**CITY OF PERU-ILLINOIS**	**VIBRATED BEAM: TOXIC WASTE CONTROL**	**IMPERMIX**	**1,100'**	**16'**	**17,600**	**available upon request**
1/96	**NUCOR-CHARLESTON, SC**	**VIBRATED BEAM: CONSTRUCTION DEWATERING**	**CEMENT BENTONITE**	**2,200'**	**30'**	**66,000**	**Norm Maero** **Nucor Steel** **704-972-1831**
***10/95**	**UNITED REFUSE-FORT WAYNE, IN**	**VIBRATED BEAM: TOXIC WASTE CONTROL**	**CEMENT BENTONITE**	**800'**	**30'**	**24,000**	**available upon request**
6/95	**IMC-PORT MAITLAND, ONT**	**VIBRATED BEAM: TOXIC WASTE CONTROL**	**IMPERMIX**	**1,400'**	**35'**	**49,000**	**available upon request**
4/95	S&W SERVICES-SHERBOURNE, NY	GATE & FUNNEL	WATERLOO® SHEET PILE	200'	25'	5,000	available upon request
	I&M SHIP CANAL-	**VIBRATED BEAM:**					**available upon**

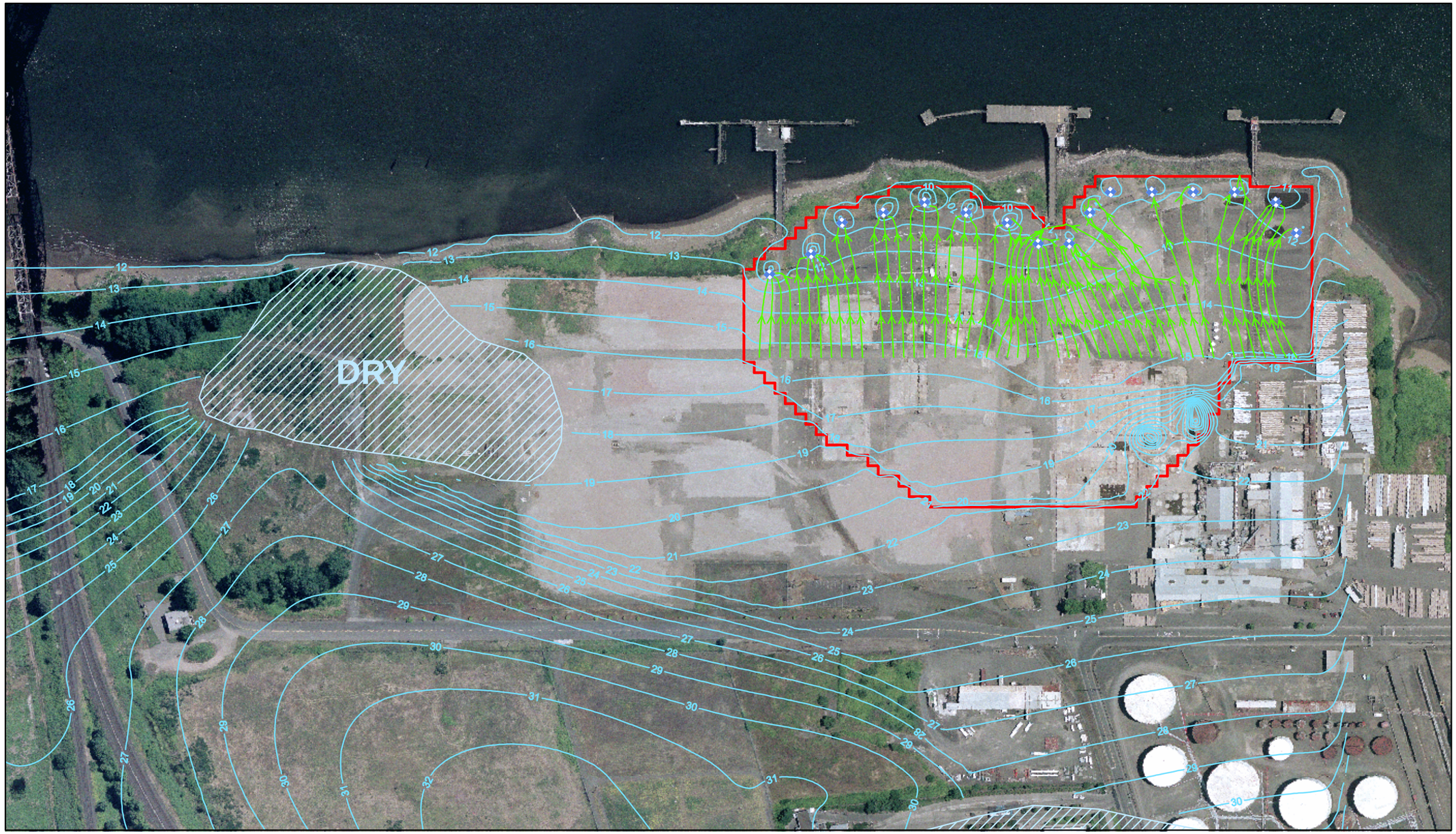
***4/95**	**CHICAGO, IL**	**TOXIC WASTE CONTROL**	**IMPERMIX**	**410'**	**21'**	**8,300**	**request**
*4/95	RUST INTER'L-PUEBLO, CO	TOXIC WASTE CONTROL	WATERLOO® SHEET PILE	145'	16'	2,320	Bob Hulet IT Corporation 925-288-9898
12/94	**MARCH AIR FORCE BASE-RIVERSIDE, CA**	**VIBRATED BEAM: WATER RETENTION**	**CEMENT BENTONITE**	**1,834'**	**15'**	**27,599**	**John O'Malley CASE Foundation 630-529-2911**
***8/94**	**FLUOR DANIEL-GARY, IN**	**VIBRATED BEAM: TOXIC WASTE CONTROL**	**IMPERMIX**	**1,576'**	**33'**	**52,000**	**available upon request**
1994	**SYLVAN LAKE**	**VIBRATED BEAM**	**-**	**-**	**-**	**-**	**Greg Holden Lawson & Fisher 219-234-3167**
11/93	IBM-BURLINGTON, VT	TOXIC WASTE CONTROL	WATERLOO® SHEET PILE	470'	14'	6,580	available upon request
08/93	**TEXACO-GUELPH, ONT, CANADA**	**VIBRATED BEAM: TOXIC WASTE CONTROL**	**JET GROUT IMPERMIX IMPERMIX/ HDPE**	**1,250' 1,140' 705'**	**16' 30' 25'**	**20,025 34,121 17,600**	**Tom Gouth Conestoga Rovers 905-712-0510**
05/92	**REGION OF PEEL-TORONTO, CANADA**	**VIBRATED BEAM: METHANE GAS BARRIER**	**CEMENT BENTONITE**	**2,600'**	**40'**	**104,000**	**available upon request**
***11/92**	**FLUOR DANIEL-FORT WAYNE, IN**	**VIBRATED BEAM: TOXIC WASTE CONTROL**	**IMPERMIX**	**1,200'**	**35'**	**42,000**	**available upon request**
***12/91**	**CITY OF TULSA-TULSA, OK**	**VIBRATED BEAM: TOXIC WASTE CONTROL**	**CEMENT BENTONITE**	**1,300'**	**25'**	**32,250**	**available upon request**
***07/91**	**MK ENVIRONMENTAL-DENVER, CO**	**VIBRATED BEAM: TOXIC WASTE CONTROL**	**IMPERMIX**	**2,000'**	**30'**	**60,000**	**available upon request**
***07/91**	**MD AMERICAN WASTE-GARY, IN**	**VIBRATED BEAM: TOXIC WASTE CONTROL**	**CEMENT BENTONITE**	**5,500'**	**33'**	**181,500**	**available upon request**
04/91	**C.D.O.H.-DENVER, CO**	**VIBRATED BEAM: METHANE GAS BARRIER**	**CEMENT BENTONITE**	**17,429'**	**14'**	**244,006**	**Tom Evered Park Construction 303-296-0240**
07/90	**SANITARY DIST.-DAYTON, OH**	**VIBRATED BEAM: CONSTRUCTION DEWATERING**	**CEMENT BENTONITE**	**1,100'**	**35'**	**38,500**	**available upon request**
11/89	M.S.D.-BLUE ISLAND, IL	CONVENTIONAL: CONSTRUCTION DEWATERING	SOIL BENTONITE	400'	14'	5,600	available upon request
08/89	DEDHAM CORP CENTER-DEDHAM, MA	CONVENTIONAL: TOXIC WASTE CONTROL	SOIL BENTONITE	800'	16'	12,800	available upon request
02/89	GENERAL MOTORS-DEFIANCE, OH	CONVENTIONAL: TOXIC WASTE CONTROL	SOIL BENTONITE	1,500'	22'	33,000	Charles Kethel ES Wagner 419-691-8651
02/88	**DOW CHEMICAL-MIDLAND, MI**	**VIBRATED BEAM: TOXIC WASTE CONTROL**	**CEMENT BENTONITE**	**1,650'**	**50'**	**82,500**	**available upon request**
08/87	**COMMONWEALTH WTR-SHORT HILLS, NJ**	**VIBRATED BEAM: WATER RETENTION (DIKE)**	**CEMENT BENTONITE**	**1,600'**	**25'**	**40,000**	**available upon request**
07/87	**MOBAY CHEMICAL-CHARLESTON, SC**	**VIBRATED BEAM: TOXIC WASTE CONTROL**	**CEMENT BENTONITE**	**1,750'**	**33'**	**57,750**	**available upon request**
04/87	**EASTERN STAINLESS STL-BALTIMORE, MD**	**VIBRATED BEAM: TOXIC WASTE CONTROL**	**CEMENT BENTONITE**	**614'**	**41'**	**25,147**	**available upon request**
10/86	**BALKEMA, INC.-INDIANAPOLIS, IN**	**VIBRATED BEAM: POLLUTION CONTROL (TEST CELL)**	**CEMENT BENTONITE**	**160'**	**100'**	**16,000**	**available upon request**

07/86	DOW CHEMICAL-SARINA, CANADA	VIBRATED BEAM: TOXIC WASTE CONTROL	ASPEMIX	774'	24'	20,124	available upon request
06/86	PUREX CORP-GARDEN CITY, NY	VIBRATED BEAM: TOXIC WASTE CONTROL	CEMENT BENTONITE	1,214'	62'	75,260	available upon request
*02/86	WATERVLIET PAPER CO.-WATERVLIET, MI	VIBRATED BEAM: FLOOD CONTROL	CEMENT BENTONITE	633'	32'	20,256	available upon request
12/85	SANITARY DIST.-MILWAUKEE, WI	VIBRATED BEAM: CONSTRUCTION DEWATERING	CEMENT BENTONITE	274'	33'	9,042	available upon request
12/85	SANITARY DIST.-MILWAUKEE, WI	VIBRATED BEAM: CONSTRUCTION DEWATERING	CEMENT BENTONITE	1,200'	35'	42,000	available upon request
11/85	SANITARY DIST.-MILWAUKEE, WI	VIBRATED BEAM: CONSTRUCTION DEWATERING	CEMENT BENTONITE	194'	32'	6,208	available upon request
*09/85	MITCHELL, SD	VIBRATED BEAM: DAM SEEPAGE CONTROL	CEMENT BENTONITE	150'	33'	4,950	available upon request
09/85	INDUSTRY-BALTIMORE, MD	VIBRATED BEAM: ACID WASTE CONTROL	ASPEMIX	1,000'	40'	40,000	available upon request
*09/85	TEXTILE MILL-THOMASTON, MD	VIBRATED BEAM: DAM SEEPAGE CONTROL	CEMENT BENTONITE	700'	60'	42,000	available upon request
*07/85	D&R CANAL-KINGSTON, NJ	VIBRATED BEAM: WATER RETENTION	CEMENT BENTONITE	3,825'	35'	133,875	available upon request
*04/85	MORTON THIOKOL-CINCINNATI, OH	VIBRATED BEAM: TOXIC WASTE CONTROL	CEMENT BENTONITE	1,040'	25'	26,000	available upon request
03/85	SANITARY DIST.-WILMIGTON, DE	VIBRATED BEAM: POLLUTION CONTROL	CEMENT BENTONITE	400'	30'	12,000	available upon request
09/84	SANITARY DIST.-MILWAUKEE, WI	VIBRATED BEAM: CONSTRUCTION DEWATERING	CEMENT BENTONITE	1,000'	35'	35,000	available upon request
1984	SACRAMENTO, CA	VIBRATED BEAM: LEVEE PROJECT	-	-	-	-	Steven Sinnock Kjeldsen & Sinnock 209-946-0268
*07/82	W.W.T.P. PUMPING STA-SHERERVILLE, IN	VIBRATED BEAM: CONSTRUCTION DEWATERING	CEMENT BENTONITE	420'	82'	34,440	Ray Miller 219-932-1611
1982	OAKES PUMPING STATION	VIBRATED BEAM	-	-	-	-	Reuben Wilske Bureau of Reclamation
1982	FEDERAL PIONEER - REGINA SASKATCHEWAN - CANADA	VIBRATED BEAM	-	-	-	-	Paul Kozicki Ground Engineering
1980	CHEVRON - RICHMOND, CA	VIBRATED BEAM	-	-	-	-	Heino Jogis
1979	MARTIN MARIETTA - CHEMICALS - NC	VIBRATED BEAM	-	-	-	-	Nick Weaver
09/75	N.I.P.S.C.O.	VIBRATED BEAM: CONSTRUCTION DEWATERING	CEMENT BENTONITE			1,000,000	Joe Kapuscinski N.I.P.S.C.O. 219-956-5113

NOTE: Slurry Systems, Inc. attempts to keep its references accurate. However, with the changing of positions & companies, it becomes nearly impossible. If there is any reference of which you need additional information, please do not hesitate to contact us at 219-938-6667.

Attachment C
Revised Groundwater Model
Head Solution Figures

GIS File:	Drawn By: T. Cota	Date: 09/04/08	Project No. 0065572



Aerial Photography - July, 2005

LEGEND

- Groundwater Flow Path
- Shallow Zone Head Solution (ft NAVD88)
- Shallow Zone Withdrawal Well
- Groundwater Barrier Wall

N True North

N Plant North

0 250 500

Feet

Figure A.3-13

Full Enclosure Groundwater Barrier Wall Installed to Top of Basalt (Layer 5)
Withdrawal Wells in Shallow Zone (Layers 1)
Arkema, Inc.
Portland, Oregon

ERM *09/08*

GIS File:	Drawn By: T. Cota	Date: 09/04/08	Project No. 0065572

Aerial Photography - July, 2005

LEGEND

- Groundwater Flow Path
- Intermediate Zone Head Solution (ft NAVD88)
- Intermediate Zone Withdrawal Well
- Groundwater Barrier Wall

True North

Plant North

0 250 500

Feet

Figure A.3-14

Full Enclosure Groundwater Barrier Wall Installed to Top of Basalt (Layer 5)
Withdrawal Wells in Intermediate Zone (Layer 3)
Arkema, Inc.
Portland, Oregon

ERM *09/08*

GIS File:	Drawn By: T. Cota	Date: 09/04/08	Project No. 0065572

Aerial Photography - July, 2005

LEGEND

- Groundwater Flow Path
- Shallow Zone Head Solution (ft NAVD88)
- Shallow Zone Withdrawal Well
- Intermediate Zone Withdrawal Well
- Groundwater Barrier Wall

True North

Plant North

0 250 500

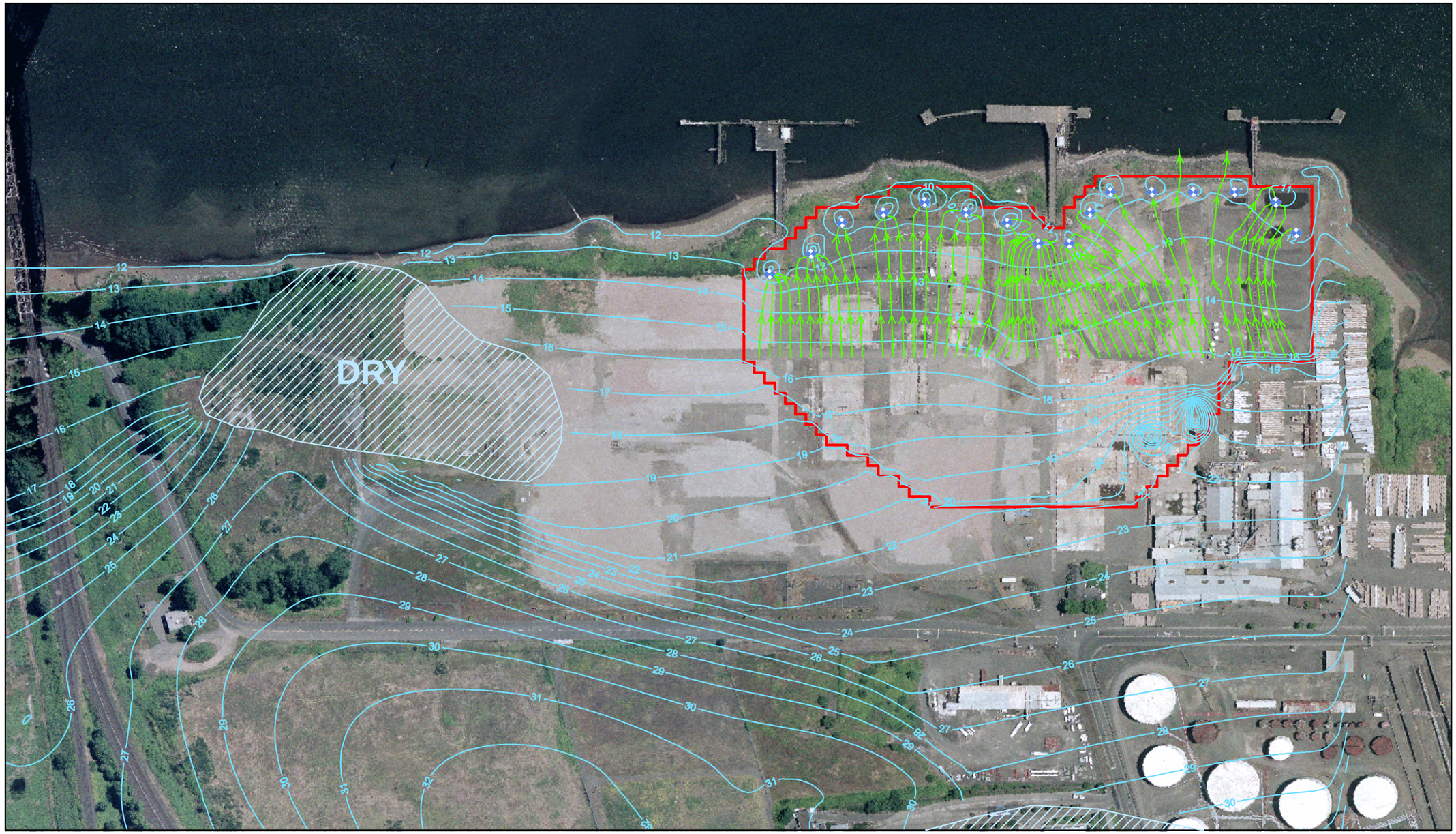
Feet

Figure A.3-15

Full Enclosure Groundwater Barrier Wall Installed to Top of Basalt (Layer 5)
Withdrawal Wells in Shallow and Intermediate Zones (Layers 1 and 3)
Arkema, Inc.
Portland, Oregon

ERM *09/08*

GIS File:	Drawn By: T. Cota	Date: 09/04/08	Project No. 0065572



Aerial Photography - July, 2005

LEGEND

- Groundwater Flow Path
- Shallow Zone Head Solution (ft NAVD88)
- Shallow Zone Withdrawal Well
- Groundwater Barrier Wall

True North

Plant North

0 250 500

Feet

Figure A.3-16

Full Enclosure Groundwater Barrier Wall Installed into Deep Zone (Layer 4)
Withdrawal Wells in Shallow Zone (Layer 1)
Arkema, Inc.
Portland, Oregon

ERM *09/08*

GIS File:	Drawn By: T. Cota	Date: 09/04/08	Project No. 0065572

Aerial Photography - July, 2005

LEGEND

- Groundwater Flow Path
- Intermediate Zone Head Solution (ft NAVD88)
- Intermediate Zone Withdrawal Well
- Groundwater Barrier Wall

True North

Plant North

0 250 500

Feet

Figure A.3-17

Full Enclosure Groundwater Barrier Wall Installed into Deep Zone (Layer 4)
Withdrawal Wells in Intermediate Zone (Layer 3)
Arkema, Inc.
Portland, Oregon

ERM *09/08*

GIS File:	Drawn By: T. Cota	Date: 09/04/08	Project No. 0065572

Aerial Photography - July, 2005

LEGEND

- Groundwater Flow Path
- Shallow Zone Head Solution (ft NAVD88)
- Shallow Zone Withdrawal Well
- Intermediate Zone Withdrawal Well
- Groundwater Barrier Wall

True North

Plant North

0 250 500

Feet

Figure A.3-18

Full Enclosure Groundwater Barrier Wall Installed into Deep Zone (Layer 4)
Withdrawal Wells in Shallow and Intermediate Zones (Layers 1 and 3)
Arkema, Inc.
Portland, Oregon

ERM *09/08*

Attachment D
Revised Slope Stability Model Computations

** PCSTABL6 **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: ENGLISH
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION ARKEMA 25 FT Trench

BOUNDARY COORDINATES

9 Top Boundaries
11 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	75.00	10.00	75.00	3
2	10.00	75.00	14.00	79.00	1
3	14.00	79.00	19.00	84.00	1
4	19.00	84.00	25.00	90.00	1
5	25.00	90.00	35.00	90.00	1
6	35.00	90.00	85.00	65.00	1
7	85.00	65.00	95.00	65.00	1
8	95.00	65.00	145.00	90.00	1
9	145.00	90.00	170.00	90.00	1
10	0.00	50.00	170.00	50.00	2
11	0.00	10.00	170.00	10.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	114.7	118.5	180.0	29.0	0.00	0.0	1
2	118.5	118.5	416.0	22.0	0.00	0.0	1

```
  3   123.1    123.1     478.4     28.0    0.00       0.0      1
1


1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED


Unit Weight of Water =  62.40


Piezometric Surface No.  1 Specified by  6 Coordinate Points


  Point      X-Water     Y-Water
   No.         (ft)        (ft)

    1          0.00       80.00
    2         55.00       80.00
    3         85.00       65.00
    4         95.00       65.00
    5        125.00       80.00
    6        170.00       80.00
1


A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.


250 Trial Surfaces Have Been Generated.


 50 Surfaces Initiate From Each Of  5 Points Equally Spaced
Along The Ground Surface Between  X =   4.00 ft.
                              and  X =  10.00 ft.


Each Surface Terminates Between   X =  30.00 ft.
                            and   X =  35.00 ft.


Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is  Y =  0.00 ft.


 4.00 ft. Line Segments Define Each Trial Failure Surface.


Restrictions Have Been Imposed Upon The Angle Of Initiation.
The Angle Has Been Restricted Between The Angles Of -25.0
And   0.0 deg.


1


Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined.  They Are Ordered - Most Critical
First.


* * Safety Factors Are Calculated By The Modified Bishop Method * *
```

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.96
3	17.92	75.76
4	21.59	77.35
5	24.85	79.67
6	27.55	82.62
7	29.58	86.07
8	30.85	89.86
9	30.86	90.00

Circle Center At X = 12.2 ; Y = 94.0 and Radius, 19.1

*** 1.628 ***

Individual data on the 11 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	4.0	957.0	1058.8	1252.7	0.0	0.0	0.0	0.0	0.0
2	3.9	2587.7	0.0	1158.3	0.0	0.0	0.0	0.0	0.0
3	1.1	941.2	0.0	294.4	0.0	0.0	0.0	0.0	0.0
4	2.6	2558.6	0.0	565.9	0.0	0.0	0.0	0.0	0.0
5	3.3	3645.2	0.0	371.8	0.0	0.0	0.0	0.0	0.0
6	0.2	178.8	0.0	3.5	0.0	0.0	0.0	0.0	0.0
7	0.1	171.1	0.0	1.1	0.0	0.0	0.0	0.0	0.0
8	2.4	2393.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	2.0	1317.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	1.3	296.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.87
3	17.94	75.56
4	21.65	77.05
5	24.98	79.26
6	27.79	82.11
7	29.96	85.47
8	31.39	89.21
9	31.51	90.00

Circle Center At X = 12.6 ; Y = 94.3 and Radius, 19.4

*** 1.642 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.94
3	17.94	75.65
4	21.67	77.08
5	25.06	79.21
6	27.99	81.93
7	30.34	85.17
8	32.04	88.79
9	32.35	90.00

Circle Center At X = 12.3 ; Y = 95.8 and Radius, 21.0

*** 1.648 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.92
3	17.94	75.59
4	21.69	76.98
5	25.12	79.05
6	28.10	81.71
7	30.53	84.89
8	32.33	88.46
9	32.77	90.00

Circle Center At X = 12.4 ; Y = 96.2 and Radius, 21.4

*** 1.658 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00

2	14.00	74.92
3	17.95	75.56
4	21.71	76.93
5	25.16	78.95
6	28.18	81.58
7	30.66	84.71
8	32.53	88.24
9	33.08	90.00

Circle Center At X = 12.5 ; Y = 96.6 and Radius, 21.7

*** 1.665 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.95
3	17.95	75.60
4	21.72	76.94
5	25.19	78.92
6	28.26	81.49
7	30.83	84.55
8	32.82	88.02
9	33.53	90.00

Circle Center At X = 12.3 ; Y = 97.5 and Radius, 22.6

*** 1.672 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.93
3	17.95	75.56
4	21.73	76.88
5	25.21	78.84
6	28.29	81.39
7	30.88	84.44
8	32.89	87.90
9	33.65	90.00

Circle Center At X = 12.4 ; Y = 97.5 and Radius, 22.6

*** 1.677 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.84
3	17.96	75.41
4	21.75	76.66
5	25.27	78.58
6	28.38	81.09
7	30.99	84.12
8	33.02	87.57
9	33.92	90.00

Circle Center At X = 12.9 ; Y = 97.1 and Radius, 22.3

*** 1.693 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	13.96	74.43
3	17.94	74.81
4	21.72	76.12
5	25.08	78.29
6	27.84	81.19
7	29.83	84.66
8	30.94	88.50
9	31.01	90.00

Circle Center At X = 14.4 ; Y = 91.2 and Radius, 16.8

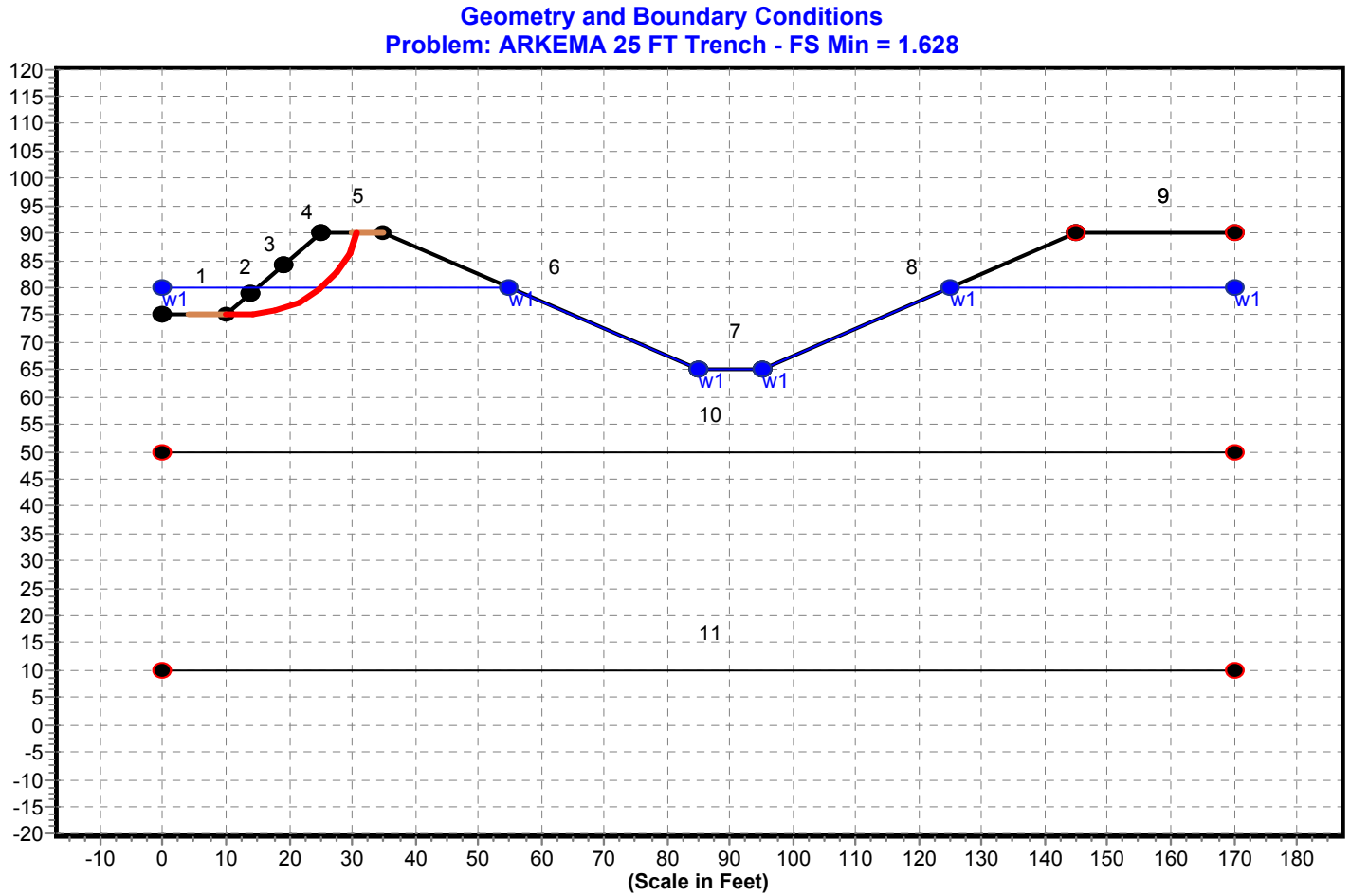
*** 1.699 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.87
3	17.96	75.42
4	21.77	76.64
5	25.31	78.50

```
    6         28.49       80.93
    7         31.21       83.87
    8         33.38       87.22
    9         34.56       90.00

Circle Center At X =   12.8 ; Y =   98.2  and Radius,   23.4


      ***     1.707   ***



1

                Y            A     X     I     S            F     T


                0.00     21.25     42.50     63.75     85.00    106.25

X        0.00 +----*----+---------+---*-----+----*--W-+---------+
              -                                  .
              -                                ..
              -                                .*
              -                                .1.*
              -                                .81   *
        21.25 +                                ..1.
              -                                 ..1..  *
              -                                  ..4121.
              -                                  ..0361
              -                                     ..*
              -
A       42.50 +
              -
              -
              -
              -                                     W
              -
X       63.75 +
              -
              -
              -
              -
              -
I       85.00 +                              *
              -
              -
              -                              *
              -
              -
S      106.25 +
              -
              -
              -
              -
              -                                     W
       127.50 +
              -
              -
              -
              -
              -                                         *
F      148.75 +
              -
```

```
                -
                -
                -
                -
T     170.00 +     *                    *              W    *
```


Geometry and Boundary Conditions
Problem: ARKEMA 25 FT Trench - FS Min = 1.628
1
2
3
4
5
6
7
8
9
10
11
w1
(Scale in Feet)

** PCSTABL6 **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: ENGLISH
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION ARKEMA

BOUNDARY COORDINATES

7 Top Boundaries
14 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	75.00	10.00	75.00	3
2	10.00	75.00	14.00	79.00	1
3	14.00	79.00	19.00	84.00	1
4	19.00	84.00	25.00	90.00	1
5	25.00	90.00	33.00	90.00	1
6	33.00	90.00	38.00	90.00	4
7	38.00	90.00	100.00	90.00	1
8	0.00	50.00	33.00	50.00	2
9	33.00	50.00	38.00	50.00	4
10	38.00	50.00	100.00	50.00	2
11	33.00	30.00	38.00	30.00	3
12	0.00	10.00	33.00	10.00	3
13	33.00	10.00	38.00	10.00	3
14	38.00	10.00	100.00	10.00	3

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.

1	114.7	118.5	180.0	29.0	0.00	0.0	1
2	118.5	118.5	416.0	22.0	0.00	0.0	1
3	123.1	123.1	478.4	28.0	0.00	0.0	1
4	75.0	80.0	0.0	18.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	80.00
2	100.00	80.00

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

250 Trial Surfaces Have Been Generated.

50 Surfaces Initiate From Each Of 5 Points Equally Spaced Along The Ground Surface Between X = 4.00 ft.
and X = 10.00 ft.

Each Surface Terminates Between X = 30.00 ft.
and X = 44.00 ft.

4.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -25.0 And 0.0 deg.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.94
3	17.93	75.67
4	21.65	77.15
5	25.00	79.34
6	27.85	82.14
7	30.09	85.45
8	31.64	89.14
9	31.82	90.00

Circle Center At X = 12.3 ; Y = 95.1 and Radius, 20.2

*** 1.483 ***

Individual data on the 11 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	4.0	962.4	1058.7	1255.6	0.0	0.0	0.0	0.0	0.0
2	3.9	2625.9	0.0	1172.6	0.0	0.0	0.0	0.0	0.0
3	1.1	944.9	0.0	295.4	0.0	0.0	0.0	0.0	0.0
4	2.6	2675.9	0.0	601.0	0.0	0.0	0.0	0.0	0.0
5	3.3	3892.1	0.0	437.9	0.0	0.0	0.0	0.0	0.0
6	0.0	5.4	0.0	0.3	0.0	0.0	0.0	0.0	0.0
7	0.7	791.3	0.0	19.2	0.0	0.0	0.0	0.0	0.0
8	2.2	2233.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	2.2	1596.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	1.5	480.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.2	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	13.98	74.62
3	17.95	75.14
4	21.70	76.53
5	25.04	78.73
6	27.81	81.62
7	29.86	85.05
8	31.09	88.86
9	31.19	90.00

Circle Center At X = 13.7 ; Y = 92.4 and Radius, 17.8

*** 1.515 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.50	74.95
3	16.44	75.63
4	20.20	77.01
5	23.64	79.05
6	26.65	81.68
7	29.14	84.82
8	31.01	88.35
9	31.53	90.00

Circle Center At X = 10.8 ; Y = 96.8 and Radius, 22.0

*** 1.583 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.50	74.91
3	16.47	75.41
4	20.32	76.50
5	23.96	78.16
6	27.31	80.34
7	30.30	82.99
8	32.86	86.07
9	34.94	89.49
10	35.15	90.00

Circle Center At X = 11.1 ; Y = 101.5 and Radius, 26.6

*** 1.595 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.50	74.80

3	16.46	75.35
4	20.25	76.61
5	23.75	78.55
6	26.83	81.10
7	29.39	84.17
8	31.34	87.67
9	32.12	90.00

Circle Center At X = 11.6 ; Y = 96.4 and Radius, 21.6

*** 1.595 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.49	74.76
3	16.47	75.16
4	20.34	76.20
5	23.99	77.83
6	27.33	80.04
7	30.27	82.74
8	32.74	85.89
9	34.68	89.39
10	34.90	90.00

Circle Center At X = 12.0 ; Y = 99.6 and Radius, 24.8

*** 1.599 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.48	74.58
3	16.46	75.01
4	20.25	76.27
5	23.69	78.30
6	26.63	81.02
7	28.92	84.30
8	30.47	87.99
9	30.84	90.00

Circle Center At X = 12.5 ; Y = 93.4 and Radius, 18.8

*** 1.600 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.48	74.56
3	16.47	74.83
4	20.34	75.81
5	23.99	77.47
6	27.27	79.74
7	30.10	82.57
8	32.38	85.86
9	34.04	89.50
10	34.17	90.00

Circle Center At X = 13.0 ; Y = 96.8 and Radius, 22.3

*** 1.612 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	13.90	74.09
3	17.90	74.18
4	21.75	75.27
5	25.20	77.28
6	28.05	80.08
7	30.11	83.51
8	31.26	87.35
9	31.36	90.00

Circle Center At X = 15.5 ; Y = 89.9 and Radius, 15.9

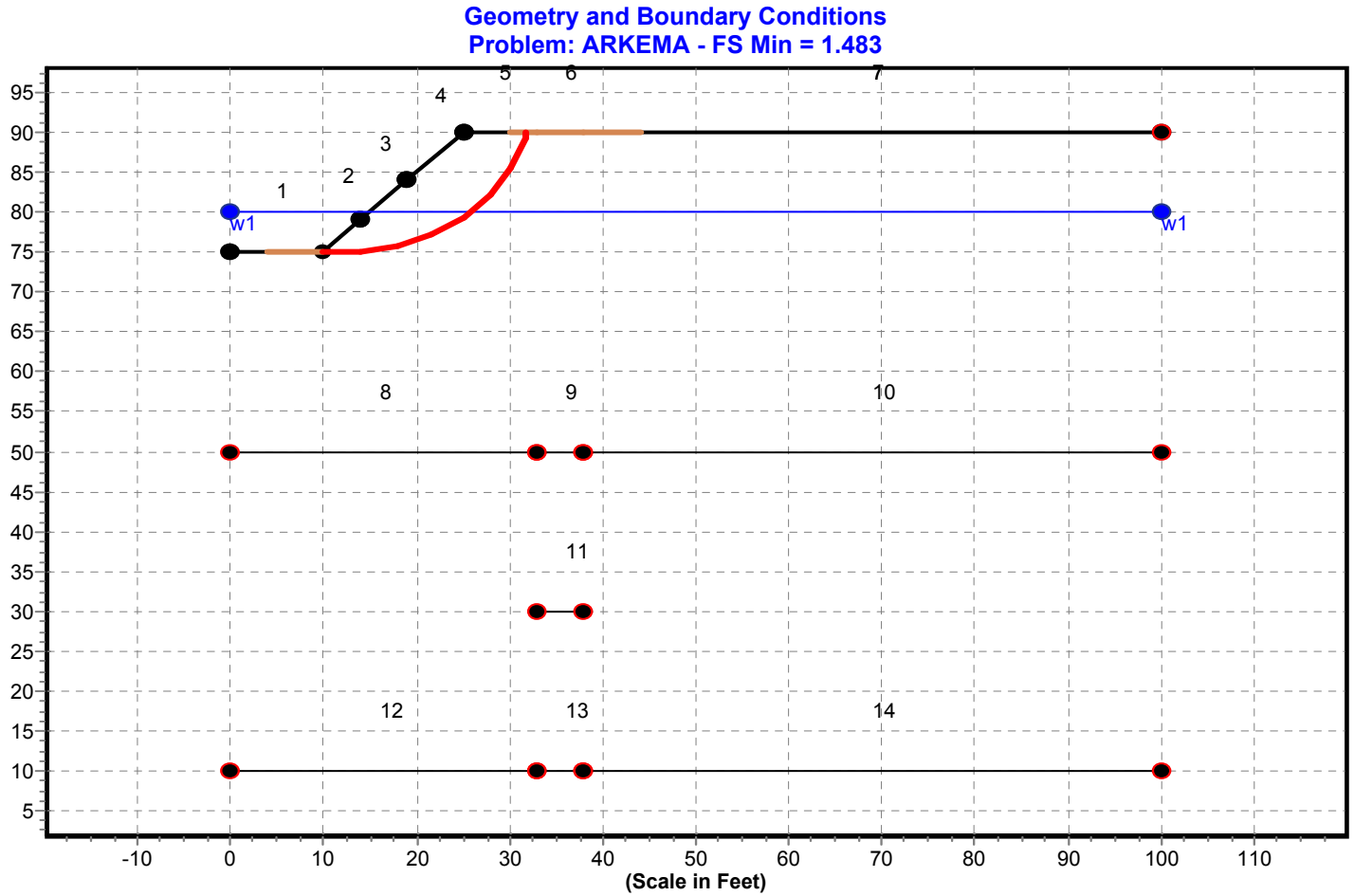
*** 1.618 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.47	74.51
3	16.46	74.75
4	20.34	75.73

```
    5         23.97       77.40
    6         27.24       79.71
    7         30.02       82.59
    8         32.23       85.92
    9         33.78       89.61
   10         33.86       90.00

Circle Center At X =   13.2 ; Y =   96.1  and Radius,   21.6


      ***     1.618   ***



1

                Y            A     X     I     S            F     T


                0.00     19.80     39.60     59.40     79.20     99.00

X        0.00 +----*----+---------+----*----+-------*-W---------+
              -                                      .
              -                                     ..
              -                                    ..*
              -                                   .91 *
              -                                   .91
        19.80 +                                   ..63  *
              -                                   ..913
              -                                    ..911.. *
              -                                    ...9.4152
              -    *         *         *            .....4.*
              -                                      ......4
A       39.60 +    *         *         *              .....*
              -                                         ....
              -
              -
              -
              -
X       59.40 +
              -
              -
              -
              -
              -
I       79.20 +
              -
              -
              -
              -
              -
S       99.00 +    *                   *              W    *
              -
              -
              -
              -
              -
      118.80 +
              -
              -
              -
              -
              -
```

```
F    138.60 +
            -
            -
            -
            -
            -
T    158.40 +
```


Geometry and Boundary Conditions
Problem: ARKEMA - FS Min = 1.483
1
2
3
4
5
6
7
8
9
10
11
12
13
14
w1
w1
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
-10
0
10
20
30
40
50
60
70
80
90
100
110
(Scale in Feet)

** PCSTABL6 **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: ENGLISH
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION Arkema 60FT VWRD

BOUNDARY COORDINATES

7 Top Boundaries
14 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	75.00	10.00	75.00	3
2	10.00	75.00	14.00	79.00	1
3	14.00	79.00	19.00	84.00	1
4	19.00	84.00	25.00	90.00	1
5	25.00	90.00	33.00	90.00	1
6	33.00	90.00	38.00	90.00	4
7	38.00	90.00	100.00	90.00	1
8	0.00	50.00	33.00	50.00	2
9	33.00	50.00	38.00	50.00	4
10	38.00	50.00	100.00	50.00	2
11	33.00	30.00	38.00	30.00	3
12	0.00	10.00	33.00	10.00	3
13	33.00	10.00	38.00	10.00	3
14	38.00	10.00	100.00	10.00	3

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.

1	114.7	118.5	180.0	29.0	0.00	0.0	1
2	118.5	118.5	416.0	22.0	0.00	0.0	1
3	123.1	123.1	478.4	28.0	0.00	0.0	1
4	75.0	80.0	0.0	18.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	75.00
2	10.00	75.00
3	15.00	80.00
4	100.00	80.00

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

250 Trial Surfaces Have Been Generated.

50 Surfaces Initiate From Each Of 5 Points Equally Spaced
Along The Ground Surface Between X = 4.00 ft.
and X = 10.00 ft.

Each Surface Terminates Between X = 30.00 ft.
and X = 44.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y =-10.00 ft.

**** ERROR - RC07 ****

4.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation.
The Angle Has Been Restricted Between The Angles Of -25.0
And 0.0 deg.

1

Y A X I S F T

```
            0.00     19.80     39.60     59.40     79.20     99.00

X      0.00 +----*----+---------+----*----+-------*-+---------+
            -
            -
            -                                     *
            -                                       *
            -                                       W
      19.80 +                                         *
            -
            -                                             *
            -
            -    *         *         *                    *
            -
A     39.60 +    *         *         *                    *
            -
            -
            -
            -
            -
X     59.40 +
            -
            -
            -
            -
            -
I     79.20 +
            -
            -
            -
            -
            -
S     99.00 +    *                   *              W    *
            -
            -
            -
            -
            -
     118.80 +
            -
            -
            -
            -
            -
F    138.60 +
            -
            -
            -
            -
            -
T    158.40 +

*****************************************
******  EXECUTION OF STABL ABORTED  ******
*****************************************
```

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.94
3	17.93	75.67
4	21.65	77.15
5	25.00	79.34
6	27.85	82.14
7	30.09	85.45
8	31.64	89.14
9	31.82	90.00

Circle Center At X = 12.3 ; Y = 95.1 and Radius, 20.2

*** 1.481 ***

Individual data on the 12 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	4.0	954.7	0.0	380.1	0.0	0.0	0.0	0.0	0.0
2	1.0	525.3	0.0	212.7	0.0	0.0	0.0	0.0	0.0
3	2.9	2094.5	0.0	857.3	0.0	0.0	0.0	0.0	0.0
4	1.1	944.9	0.0	295.4	0.0	0.0	0.0	0.0	0.0
5	2.6	2675.9	0.0	601.0	0.0	0.0	0.0	0.0	0.0
6	3.3	3892.1	0.0	437.9	0.0	0.0	0.0	0.0	0.0
7	0.0	5.4	0.0	0.3	0.0	0.0	0.0	0.0	0.0
8	0.7	791.3	0.0	19.2	0.0	0.0	0.0	0.0	0.0
9	2.2	2233.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	2.2	1596.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	1.5	480.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.2	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	13.98	74.62
3	17.95	75.14
4	21.70	76.53
5	25.04	78.73
6	27.81	81.62
7	29.86	85.05

8	31.09	88.86
9	31.19	90.00

Circle Center At X = 13.7 ; Y = 92.4 and Radius, 17.8

*** 1.502 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.48	74.58
3	16.46	75.01
4	20.25	76.27
5	23.69	78.30
6	26.63	81.02
7	28.92	84.30
8	30.47	87.99
9	30.84	90.00

Circle Center At X = 12.5 ; Y = 93.4 and Radius, 18.8

*** 1.567 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.50	74.95
3	16.44	75.63
4	20.20	77.01
5	23.64	79.05
6	26.65	81.68
7	29.14	84.82
8	31.01	88.35
9	31.53	90.00

Circle Center At X = 10.8 ; Y = 96.8 and Radius, 22.0

*** 1.569 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.50	74.80
3	16.46	75.35
4	20.25	76.61
5	23.75	78.55
6	26.83	81.10
7	29.39	84.17
8	31.34	87.67
9	32.12	90.00

Circle Center At X = 11.6 ; Y = 96.4 and Radius, 21.6

*** 1.578 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.43	74.24
3	16.42	74.44
4	20.25	75.59
5	23.70	77.63
6	26.56	80.42
7	28.67	83.82
8	29.91	87.62
9	30.08	90.00

Circle Center At X = 13.6 ; Y = 90.8 and Radius, 16.6

*** 1.584 ***

1

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.49	74.76
3	16.47	75.16
4	20.34	76.20
5	23.99	77.83
6	27.33	80.04
7	30.27	82.74
8	32.74	85.89
9	34.68	89.39
10	34.90	90.00

Circle Center At X = 12.0 ; Y = 99.6 and Radius, 24.8

*** 1.586 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.50	74.91
3	16.47	75.41
4	20.32	76.50
5	23.96	78.16
6	27.31	80.34
7	30.30	82.99
8	32.86	86.07
9	34.94	89.49
10	35.15	90.00

Circle Center At X = 11.1 ; Y = 101.5 and Radius, 26.6

*** 1.587 ***

1

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.48	74.56
3	16.47	74.83
4	20.34	75.81
5	23.99	77.47
6	27.27	79.74
7	30.10	82.57
8	32.38	85.86
9	34.04	89.50
10	34.17	90.00

Circle Center At X = 13.0 ; Y = 96.8 and Radius, 22.3

*** 1.592 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.46	74.43
3	16.45	74.69
4	20.30	75.77
5	23.84	77.63
6	26.92	80.18
7	29.40	83.32
8	31.17	86.91
9	31.96	90.00

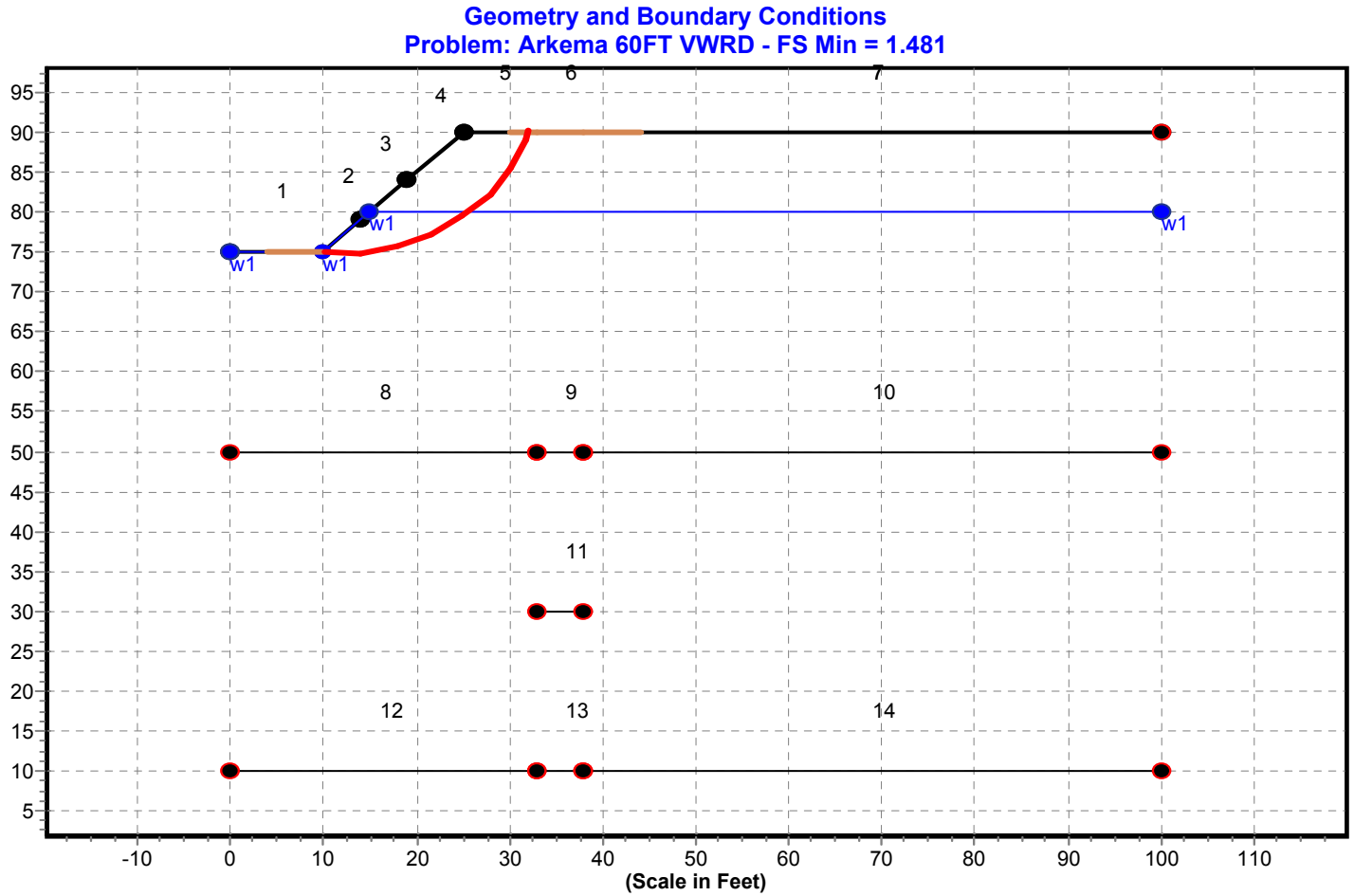
Circle Center At X = 13.2 ; Y = 93.6 and Radius, 19.1

*** 1.594 ***

1

```
            Y            A     X     I     S            F     T

            0.00     19.80     39.60     59.40     79.20     99.00

X      0.00 +----*----+---------+----*----+-------*-+---------+
            -                                      .
            -                                     ..
            -                                    ..*
            -                                    .61 *
            -                                    ..1 W
      19.80 +                                    ..63  *
            -                                    ...13
            -                                     ...11.. *
            -                                     .....6132
            -    *         *         *             .....7.*
            -                                       ......7
A     39.60 +    *         *         *              .....*
            -                                          ....
            -
            -
            -
            -
X     59.40 +
            -
            -
            -
            -
            -
I     79.20 +
            -
            -
            -
            -
            -
S     99.00 +    *                   *              W    *
            -
            -
            -
            -
            -
```

```
     118.80 +
            -
            -
            -
            -
            -
F    138.60 +
            -
            -
            -
            -
            -
T    158.40 +
```


Geometry and Boundary Conditions
Problem: Arkema 60FT VWRD - FS Min = 1.481
1
2
3
4
5
6
7
8
9
10
11
12
13
14
w1
w1
w1
w1
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
-10
0
10
20
30
40
50
60
70
80
90
100
110
(Scale in Feet)

90ftVWresult.out.txt
** PCSTABL6 **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: ENGLISH
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION Arkema 90 FT VW

BOUNDARY COORDINATES

7 Top Boundaries
13 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	75.00	10.00	75.00	3
2	10.00	75.00	14.00	79.00	1
3	14.00	79.00	19.00	84.00	1
4	19.00	84.00	25.00	90.00	1
5	25.00	90.00	35.00	90.00	1
6	35.00	90.00	40.00	90.00	4
7	40.00	90.00	100.00	90.00	1
8	0.00	50.00	35.00	50.00	2
9	35.00	50.00	40.00	50.00	4
10	40.00	50.00	100.00	50.00	2
11	0.00	10.00	35.00	10.00	3
12	35.00	10.00	40.00	10.00	4
13	40.00	10.00	100.00	10.00	3

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.

1	114.7	118.5	180.0	29.0	0.00	0.0	1
2	118.5	118.5	416.0	22.0	0.00	0.0	1
3	123.1	123.1	478.4	28.0	0.00	0.0	1
4	75.0	80.0	0.0	18.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	80.00
2	100.00	80.00

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

250 Trial Surfaces Have Been Generated.

50 Surfaces Initiate From Each Of 5 Points Equally Spaced Along The Ground Surface Between X = 4.00 ft.
and X = 10.00 ft.

Each Surface Terminates Between X = 32.00 ft.
and X = 44.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00 ft.

4.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -25.0 And 0.0 deg.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.94
3	17.95	75.58
4	21.72	76.91
5	25.20	78.88
6	28.28	81.43
7	30.87	84.48
8	32.87	87.95
9	33.62	90.00

Circle Center At X = 12.3 ; Y = 97.5 and Radius, 22.7

*** 1.675 ***

Individual data on the 11 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	4.0	962.4	1058.7	1255.6	0.0	0.0	0.0	0.0	0.0
2	3.9	2658.5	0.0	1183.0	0.0	0.0	0.0	0.0	0.0
3	1.1	946.9	0.0	294.6	0.0	0.0	0.0	0.0	0.0
4	2.7	2824.6	0.0	642.6	0.0	0.0	0.0	0.0	0.0
5	3.3	3984.6	0.0	508.6	0.0	0.0	0.0	0.0	0.0
6	0.2	260.7	0.0	17.1	0.0	0.0	0.0	0.0	0.0
7	1.4	1642.0	0.0	61.5	0.0	0.0	0.0	0.0	0.0
8	1.7	1839.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	2.6	2086.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	2.0	871.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.7	88.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.91
3	17.97	75.41
4	21.81	76.51
5	25.45	78.17
6	28.80	80.35
7	31.79	83.01
8	34.34	86.09
9	36.41	89.52
10	36.61	90.00

Circle Center At X = 12.6 ; Y = 101.4 and Radius, 26.6

*** 1.717 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.50	74.95
3	16.45	75.55
4	20.26	76.79
5	23.81	78.62
6	27.02	81.01
7	29.80	83.88
8	32.08	87.17
9	33.42	90.00

Circle Center At X = 10.8 ; Y = 99.5 and Radius, 24.6

*** 1.765 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.48	74.59
3	16.46	74.95
4	20.30	76.07
5	23.86	77.90
6	27.00	80.38
7	29.60	83.42
8	31.58	86.90
9	32.61	90.00

Circle Center At X = 12.6 ; Y = 95.4 and Radius, 20.8

*** 1.769 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00

2	12.48	74.58
3	16.46	74.92
4	20.31	76.02
5	23.88	77.83
6	27.04	80.28
7	29.67	83.29
8	31.68	86.75
9	32.82	90.00

Circle Center At X = 12.7 ; Y = 95.5 and Radius, 20.9

*** 1.773 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.45	74.39
3	16.45	74.58
4	20.33	75.55
5	23.94	77.27
6	27.14	79.67
7	29.81	82.65
8	31.84	86.10
9	33.14	89.88
10	33.16	90.00

Circle Center At X = 13.5 ; Y = 94.5 and Radius, 20.2

*** 1.797 ***

1

Failure Surface Specified By 10 Coordinate Points

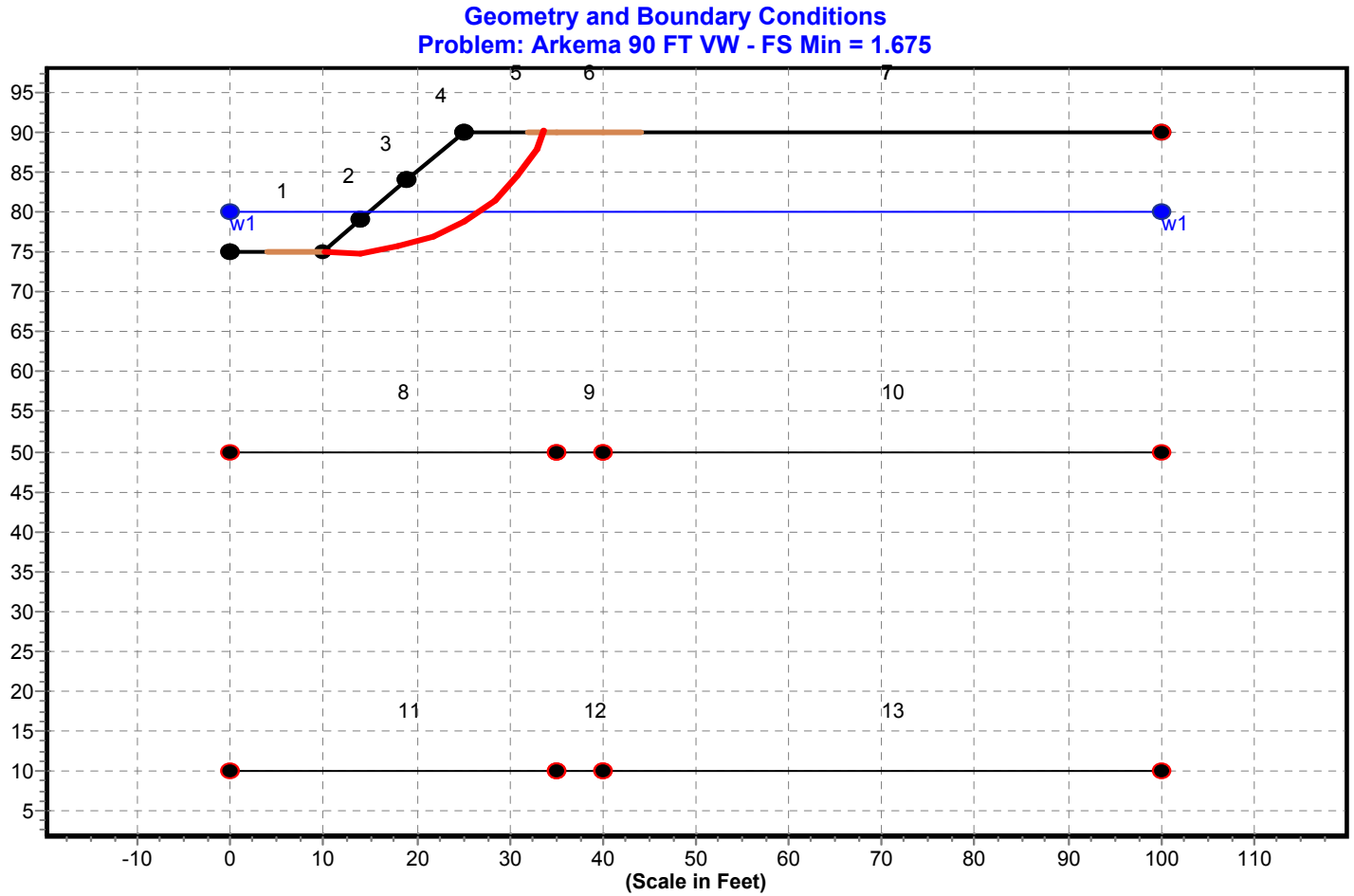
Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.46	74.43
3	16.45	74.61
4	20.34	75.55
5	23.99	77.20
6	27.25	79.51
7	30.02	82.40
8	32.19	85.76
9	33.68	89.47
10	33.79	90.00

Circle Center At X = 13.5 ; Y = 95.4 and Radius, 21.0

```
      ***     1.803   ***



Failure Surface Specified By  9 Coordinate Points

  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)

    1          8.50       75.00
    2         12.43       74.24
    3         16.43       74.35
    4         20.31       75.32
    5         23.89       77.10
    6         27.00       79.61
    7         29.50       82.74
    8         31.26       86.33
    9         32.15       90.00

Circle Center At X =   13.9 ; Y =   92.6  and Radius,   18.4


      ***     1.805   ***



1

Failure Surface Specified By 10 Coordinate Points

  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)

    1          8.50       75.00
    2         12.48       74.56
    3         16.47       74.77
    4         20.37       75.64
    5         24.08       77.14
    6         27.50       79.23
    7         30.52       81.85
    8         33.07       84.93
    9         35.08       88.38
   10         35.70       90.00

Circle Center At X =   13.2 ; Y =   98.7  and Radius,   24.1


      ***     1.810   ***



Failure Surface Specified By  9 Coordinate Points

  Point      X-Surf      Y-Surf
   No.        (ft)        (ft)

    1         10.00       75.00
    2         13.90       74.09
```

```
    3         17.90       74.09
    4         21.79       75.00
    5         25.38       76.77
    6         28.47       79.31
    7         30.90       82.49
    8         32.55       86.13
    9         33.31       90.00

Circle Center At X =   15.9 ; Y =   91.5  and Radius,   17.5


      ***     1.816   ***



1

                Y            A     X     I     S            F     T


                0.00     19.80     39.60     59.40     79.20     99.00

X        0.00 +----*----+---------+----*----+-------*-W---------+
              -                                       .
              -                                      ..
              -                                     ..*
              -                                    .81 *
              -                                    .01.
        19.80 +                                    ..43  *
              -                                    ..013.
              -                                     ..213.  *
              -                                     ...01318
              -                                      ....2211
              -    *                   *             ......*
A       39.60 +    *                   *              .....*
              -                                        ....
              -
              -
              -
              -
X       59.40 +
              -
              -
              -
              -
              -
I       79.20 +
              -
              -
              -
              -
              -
S       99.00 +    *                   *              W    *
              -
              -
              -
              -
              -
       118.80 +
              -
              -
              -
              -
```

```
                -
F     138.60 +
                -
                -
                -
                -
                -
T     158.40 +
```


Geometry and Boundary Conditions
Problem: Arkema 90 FT VW - FS Min = 1.675
1
2
3
4
5
6
7
8
9
10
11
12
13
w1
w1
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
-10
0
10
20
30
40
50
60
70
80
90
100
110
(Scale in Feet)

** PCSTABL6 **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: ENGLISH
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION ARKEMA

BOUNDARY COORDINATES

7 Top Boundaries
13 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	75.00	10.00	75.00	3
2	10.00	75.00	14.00	79.00	1
3	14.00	79.00	19.00	84.00	1
4	19.00	84.00	25.00	90.00	1
5	25.00	90.00	35.00	90.00	1
6	35.00	90.00	40.00	90.00	4
7	40.00	90.00	100.00	90.00	1
8	0.00	50.00	35.00	50.00	2
9	35.00	50.00	40.00	50.00	4
10	40.00	50.00	100.00	50.00	2
11	0.00	10.00	35.00	10.00	3
12	35.00	10.00	40.00	10.00	4
13	40.00	10.00	100.00	10.00	3

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.

1	114.7	118.5	180.0	29.0	0.00	0.0	1
2	118.5	118.5	416.0	22.0	0.00	0.0	1
3	123.1	123.1	478.4	28.0	0.00	0.0	1
4	75.0	80.0	0.0	18.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	75.00
2	10.00	75.00
3	15.00	80.00
4	100.00	80.00

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

250 Trial Surfaces Have Been Generated.

50 Surfaces Initiate From Each Of 5 Points Equally Spaced Along The Ground Surface Between X = 4.00 ft.
and X = 10.00 ft.

Each Surface Terminates Between X = 32.00 ft.
and X = 44.00 ft.

4.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -25.0 And 0.0 deg.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.94
3	17.95	75.58
4	21.72	76.91
5	25.20	78.88
6	28.28	81.43
7	30.87	84.48
8	32.87	87.95
9	33.62	90.00

Circle Center At X = 12.3 ; Y = 97.5 and Radius, 22.7

*** 1.525 ***

Individual data on the 12 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	4.0	954.7	0.0	380.1	0.0	0.0	0.0	0.0	0.0
2	1.0	526.6	0.0	212.4	0.0	0.0	0.0	0.0	0.0
3	2.9	2125.8	0.0	868.2	0.0	0.0	0.0	0.0	0.0
4	1.1	946.9	0.0	294.6	0.0	0.0	0.0	0.0	0.0
5	2.7	2824.6	0.0	642.6	0.0	0.0	0.0	0.0	0.0
6	3.3	3984.6	0.0	508.6	0.0	0.0	0.0	0.0	0.0
7	0.2	260.7	0.0	17.1	0.0	0.0	0.0	0.0	0.0
8	1.4	1642.0	0.0	61.5	0.0	0.0	0.0	0.0	0.0
9	1.7	1839.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	2.6	2086.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	2.0	871.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.7	88.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.91
3	17.97	75.41
4	21.81	76.51
5	25.45	78.17
6	28.80	80.35
7	31.79	83.01
8	34.34	86.09
9	36.41	89.52
10	36.61	90.00

Circle Center At X = 12.6 ; Y = 101.4 and Radius, 26.6

*** 1.577 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.48	74.59
3	16.46	74.95
4	20.30	76.07
5	23.86	77.90
6	27.00	80.38
7	29.60	83.42
8	31.58	86.90
9	32.61	90.00

Circle Center At X = 12.6 ; Y = 95.4 and Radius, 20.8

*** 1.594 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.48	74.58
3	16.46	74.92
4	20.31	76.02
5	23.88	77.83
6	27.04	80.28
7	29.67	83.29
8	31.68	86.75
9	32.82	90.00

Circle Center At X = 12.7 ; Y = 95.5 and Radius, 20.9

*** 1.599 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00

2	12.50	74.95
3	16.45	75.55
4	20.26	76.79
5	23.81	78.62
6	27.02	81.01
7	29.80	83.88
8	32.08	87.17
9	33.42	90.00

Circle Center At X = 10.8 ; Y = 99.5 and Radius, 24.6

*** 1.605 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.43	74.24
3	16.43	74.35
4	20.31	75.32
5	23.89	77.10
6	27.00	79.61
7	29.50	82.74
8	31.26	86.33
9	32.15	90.00

Circle Center At X = 13.9 ; Y = 92.6 and Radius, 18.4

*** 1.616 ***

1

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.45	74.39
3	16.45	74.58
4	20.33	75.55
5	23.94	77.27
6	27.14	79.67
7	29.81	82.65
8	31.84	86.10
9	33.14	89.88
10	33.16	90.00

Circle Center At X = 13.5 ; Y = 94.5 and Radius, 20.2

*** 1.619 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.46	74.43
3	16.45	74.61
4	20.34	75.55
5	23.99	77.20
6	27.25	79.51
7	30.02	82.40
8	32.19	85.76
9	33.68	89.47
10	33.79	90.00

Circle Center At X = 13.5 ; Y = 95.4 and Radius, 21.0

*** 1.629 ***

1

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.39	74.06
3	16.39	74.00
4	20.30	74.85
5	23.92	76.54
6	27.07	79.00
7	29.60	82.10
8	31.37	85.69
9	32.29	89.58
10	32.29	90.00

Circle Center At X = 14.6 ; Y = 91.7 and Radius, 17.7

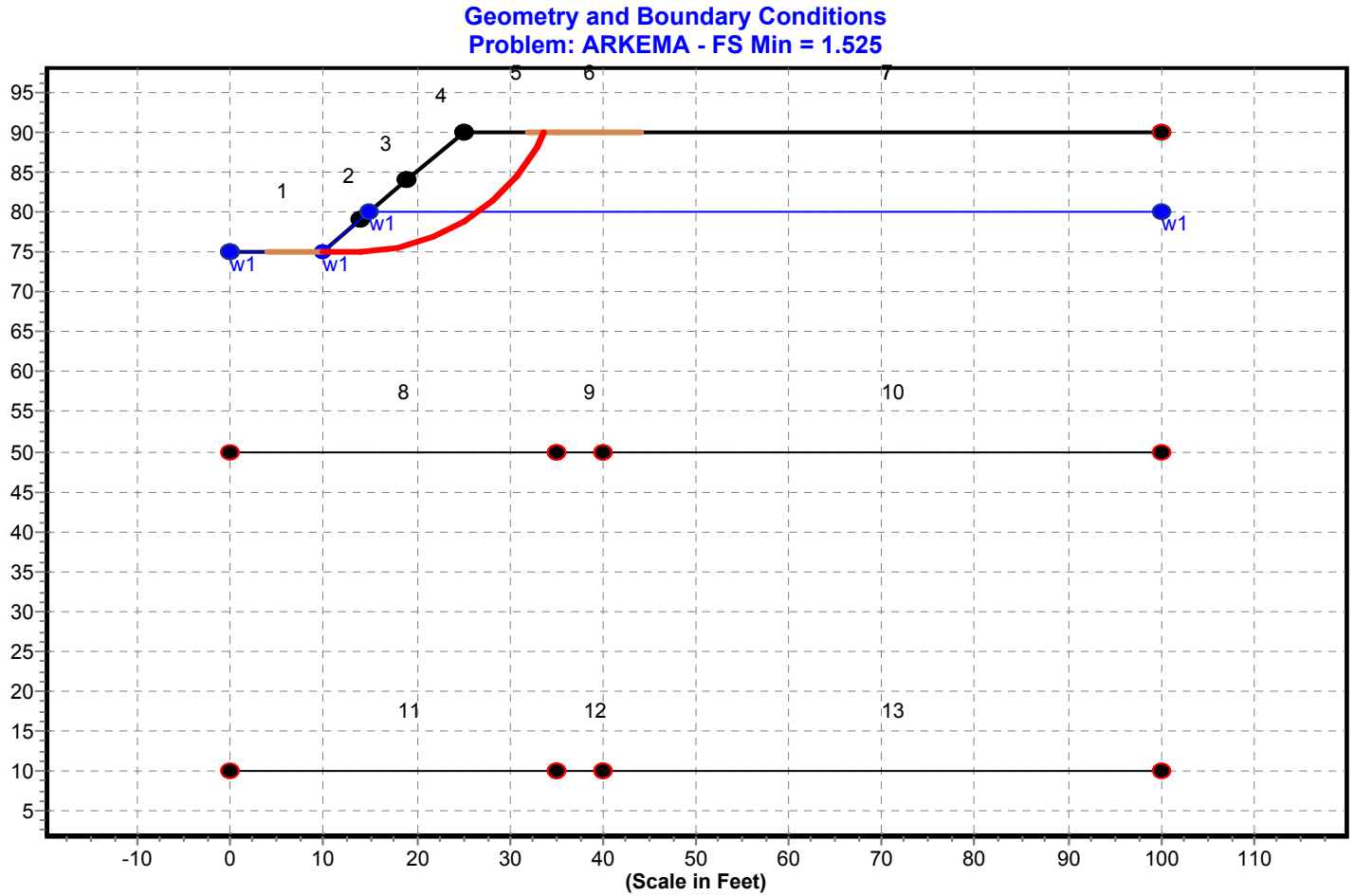
*** 1.642 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	13.90	74.09

```
    3         17.90       74.09
    4         21.79       75.00
    5         25.38       76.77
    6         28.47       79.31
    7         30.90       82.49
    8         32.55       86.13
    9         33.31       90.00

Circle Center At X =   15.9 ; Y =   91.5  and Radius,   17.5


      ***     1.645   ***



1

                Y            A     X     I     S            F     T


                0.00     19.80     39.60     59.40     79.20     99.00

X        0.00 +----*----+---------+----*----+-------*-+---------+
              -                                       .
              -                                      ..
              -                                     ..*
              -                                    .61 *
              -                                    .91.W
        19.80 +                                    ..35  *
              -                                    ..015.
              -                                     ..213.  *
              -                                     ...01316
              -                                      ....2211
              -    *                   *             ......*
A       39.60 +    *                   *              .....*
              -                                        ....
              -
              -
              -
              -
X       59.40 +
              -
              -
              -
              -
              -
I       79.20 +
              -
              -
              -
              -
              -
S       99.00 +    *                   *              W    *
              -
              -
              -
              -
              -
      118.80 +
              -
              -
              -
              -
```

```
                -
F     138.60 +
                -
                -
                -
                -
                -
T     158.40 +
```


Geometry and Boundary Conditions
Problem: ARKEMA - FS Min = 1.525
1
2
3
4
5
6
7
8
9
10
11
12
13
w1
w1
w1
w1
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
-10
0
10
20
30
40
50
60
70
80
90
100
110
(Scale in Feet)

** PCSTABL6 **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: ENGLISH
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION ARKEMA

BOUNDARY COORDINATES

5 Top Boundaries
7 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	75.00	10.00	75.00	3
2	10.00	75.00	14.00	79.00	1
3	14.00	79.00	19.00	84.00	1
4	19.00	84.00	25.00	90.00	1
5	25.00	90.00	100.00	90.00	1
6	0.00	50.00	100.00	50.00	2
7	0.00	10.00	100.00	10.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	114.7	118.5	180.0	29.0	0.00	0.0	1
2	118.5	118.5	416.0	22.0	0.00	0.0	1
3	123.1	123.1	478.4	28.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	80.00
2	100.00	80.00

1

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	47.00	62.00	234900.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed
Force Acting On A Horizontally Projected Surface.

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

250 Trial Surfaces Have Been Generated.

50 Surfaces Initiate From Each Of 5 Points Equally Spaced
Along The Ground Surface Between X = 4.00 ft.
and X = 10.00 ft.

Each Surface Terminates Between X = 28.00 ft.
and X = 46.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

4.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation.
The Angle Has Been Restricted Between The Angles Of -25.0
And 0.0 deg.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.94
3	17.92	75.75
4	21.56	77.41
5	24.75	79.82
6	27.34	82.87
7	29.19	86.41
8	30.15	90.00

Circle Center At X = 12.3 ; Y = 93.0 and Radius, 18.1

*** 1.627 ***

Individual data on the 10 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	4.0	962.4	1058.7	1255.6	0.0	0.0	0.0	0.0	0.0
2	3.9	2589.6	0.0	1161.5	0.0	0.0	0.0	0.0	0.0
3	1.1	943.7	0.0	297.1	0.0	0.0	0.0	0.0	0.0
4	2.6	2510.9	0.0	556.2	0.0	0.0	0.0	0.0	0.0
5	3.2	3509.6	0.0	346.1	0.0	0.0	0.0	0.0	0.0
6	0.2	174.6	0.0	1.3	0.0	0.0	0.0	0.0	0.0
7	0.1	109.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	2.3	2280.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	1.9	1140.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	1.0	197.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.79
3	17.95	75.40
4	21.70	76.80
5	25.09	78.92

6	27.97	81.69
7	30.24	84.99
8	31.79	88.68
9	32.05	90.00

Circle Center At X = 13.0 ; Y = 94.4 and Radius, 19.6

*** 1.659 ***

1

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	13.98	74.62
3	17.93	75.24
4	21.61	76.82
5	24.78	79.26
6	27.24	82.41
7	28.84	86.07
8	29.49	90.00

Circle Center At X = 13.5 ; Y = 90.6 and Radius, 16.0

*** 1.666 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.91
3	17.96	75.49
4	21.76	76.72
5	25.31	78.58
6	28.49	81.00
7	31.22	83.92
8	33.42	87.26
9	34.63	90.00

Circle Center At X = 12.5 ; Y = 98.6 and Radius, 23.8

*** 1.705 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.50	74.95
3	16.43	75.71
4	20.12	77.25
5	23.42	79.51
6	26.20	82.39
7	28.34	85.77
8	29.75	89.51
9	29.83	90.00

Circle Center At X = 10.7 ; Y = 94.5 and Radius, 19.7

*** 1.744 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.48	74.58
3	16.44	75.10
4	20.17	76.54
5	23.46	78.82
6	26.12	81.81
7	28.01	85.34
8	29.01	89.21
9	29.03	90.00

Circle Center At X = 12.3 ; Y = 91.5 and Radius, 16.9

*** 1.764 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.46	74.43
3	16.44	74.76
4	20.25	76.00
5	23.67	78.07
6	26.54	80.86
7	28.69	84.23
8	30.03	88.00
9	30.25	90.00

Circle Center At X = 13.0 ; Y = 91.9 and Radius, 17.5

*** 1.767 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.45	74.39
3	16.44	74.76
4	20.22	76.06
5	23.58	78.23
6	26.32	81.15
7	28.28	84.64
8	29.34	88.49
9	29.39	90.00

Circle Center At X = 13.0 ; Y = 90.9 and Radius, 16.6

*** 1.772 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.45	74.40
3	16.45	74.67
4	20.28	75.80
5	23.78	77.74
6	26.78	80.39
7	29.12	83.63
8	30.71	87.30
9	31.23	90.00

Circle Center At X = 13.2 ; Y = 92.7 and Radius, 18.3

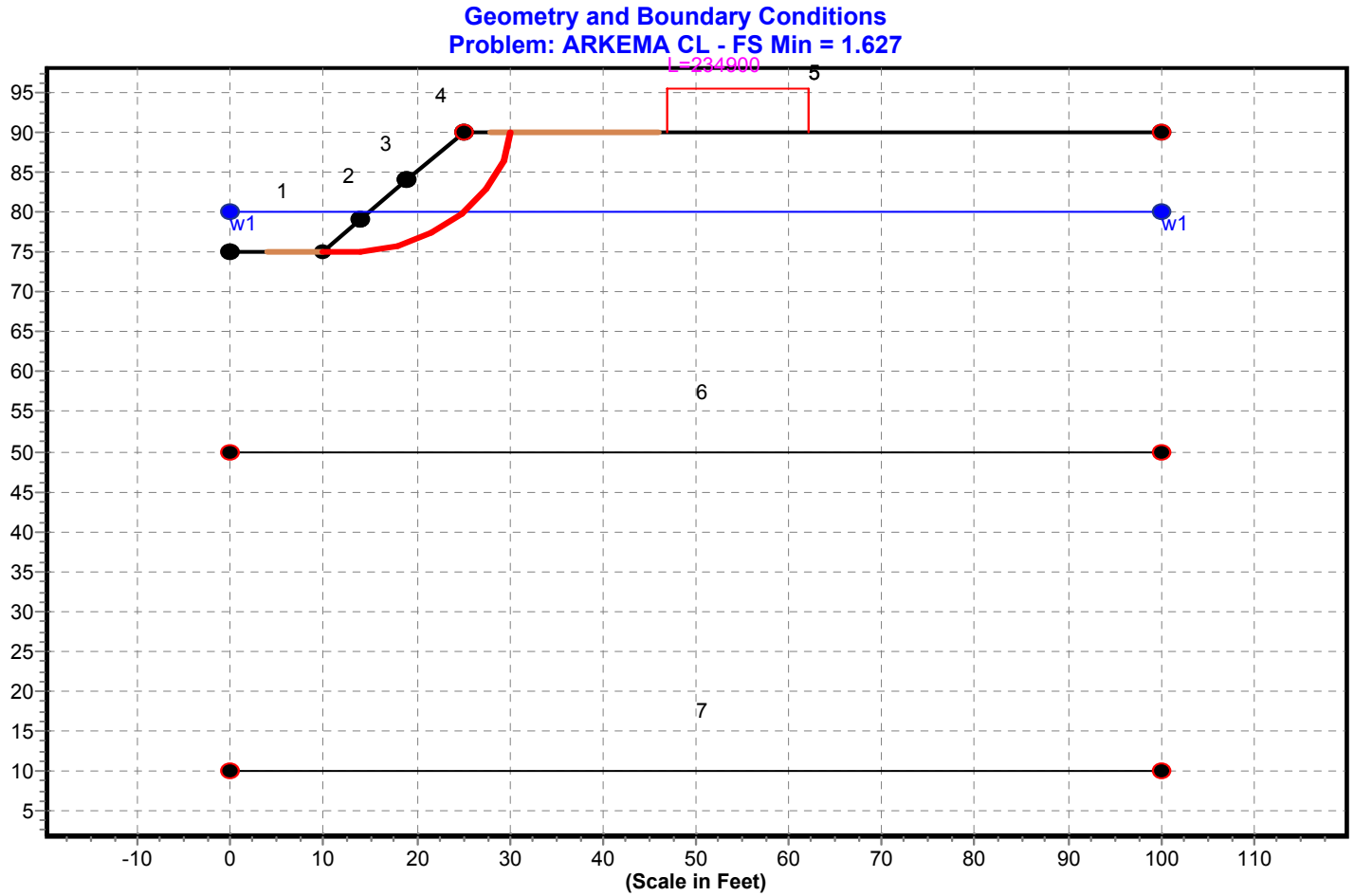
*** 1.774 ***

Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |

```
    1          8.50       75.00
    2         12.47       74.51
    3         16.46       74.81
    4         20.31       75.89
    5         23.87       77.71
    6         27.00       80.19
    7         29.59       83.25
    8         31.51       86.75
    9         32.53       90.00

Circle Center At X =   13.0 ; Y =   94.7  and Radius,   20.2


      ***     1.775   ***



1

                Y            A     X     I     S            F     T


                0.00     21.06     42.13     63.19     84.26    105.32

X        0.00 +----*----+---------+---*-----+-----*-W-+---------+
              -                                     .
              -                                    .5
              -                                  ..*
              -                                  .31 *
              -                                  .71   *
        21.06 +                                  ..21.
              -                                  ...215   *
              -                                  ....417153
              -                                   .....2921
              -                                    .....4.4
              -                                     .......
A       42.13 +                                       .....
              -                                          .../1
              -
              -
              -
              -
X       63.19 +                                             1/
              -
              -
              -
              -
              -
I       84.26 +
              -
              -
              -
              -    *                   *             W    *
              -
S      105.32 +
              -
              -
              -
              -
              -
       126.38 +
              -
```

```
                -
                -
                -
                -
F     147.45 +
                -
                -
                -
                -
                -
T     168.51 +
```


Geometry and Boundary Conditions
Problem: ARKEMA CL - FS Min = 1.627
L=234900
5
4
3
2
1
w1
w1
6
7
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
-10
0
10
20
30
40
50
60
70
80
90
100
110
(Scale in Feet)

** PCSTABL6 **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: ENGLISH
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION ARKEMA

BOUNDARY COORDINATES

5 Top Boundaries
7 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	75.00	10.00	75.00	3
2	10.00	75.00	14.00	79.00	1
3	14.00	79.00	19.00	84.00	1
4	19.00	84.00	25.00	90.00	1
5	25.00	90.00	100.00	90.00	1
6	0.00	50.00	100.00	50.00	2
7	0.00	10.00	100.00	10.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	114.7	118.5	180.0	29.0	0.00	0.0	1
2	118.5	118.5	416.0	22.0	0.00	0.0	1
3	123.1	123.1	478.4	28.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	75.00
2	10.00	75.00
3	15.00	80.00
4	100.00	80.00

1

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	47.00	62.00	234900.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed
Force Acting On A Horizontally Projected Surface.

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

250 Trial Surfaces Have Been Generated.

50 Surfaces Initiate From Each Of 5 Points Equally Spaced
Along The Ground Surface Between X = 4.00 ft.
and X = 10.00 ft.

Each Surface Terminates Between X = 28.00 ft.
and X = 46.00 ft.

4.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation.
The Angle Has Been Restricted Between The Angles Of -25.0
And 0.0 deg.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.94
3	17.92	75.75
4	21.56	77.41
5	24.75	79.82
6	27.34	82.87
7	29.19	86.41
8	30.15	90.00

Circle Center At X = 12.3 ; Y = 93.0 and Radius, 18.1

*** 1.456 ***

Individual data on the 11 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	4.0	954.7	0.0	380.1	0.0	0.0	0.0	0.0	0.0
2	1.0	523.9	0.0	213.1	0.0	0.0	0.0	0.0	0.0
3	2.9	2059.6	0.0	845.5	0.0	0.0	0.0	0.0	0.0
4	1.1	943.7	0.0	297.1	0.0	0.0	0.0	0.0	0.0
5	2.6	2510.9	0.0	556.2	0.0	0.0	0.0	0.0	0.0
6	3.2	3509.6	0.0	346.1	0.0	0.0	0.0	0.0	0.0
7	0.2	174.6	0.0	1.3	0.0	0.0	0.0	0.0	0.0
8	0.1	109.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	2.3	2280.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	1.9	1140.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	1.0	197.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	13.98	74.62
3	17.93	75.24
4	21.61	76.82
5	24.78	79.26

6	27.24	82.41
7	28.84	86.07
8	29.49	90.00

Circle Center At X = 13.5 ; Y = 90.6 and Radius, 16.0

*** 1.482 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.79
3	17.95	75.40
4	21.70	76.80
5	25.09	78.92
6	27.97	81.69
7	30.24	84.99
8	31.79	88.68
9	32.05	90.00

Circle Center At X = 13.0 ; Y = 94.4 and Radius, 19.6

*** 1.500 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.48	74.58
3	16.44	75.10
4	20.17	76.54
5	23.46	78.82
6	26.12	81.81
7	28.01	85.34
8	29.01	89.21
9	29.03	90.00

Circle Center At X = 12.3 ; Y = 91.5 and Radius, 16.9

*** 1.557 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.91
3	17.96	75.49
4	21.76	76.72
5	25.31	78.58
6	28.49	81.00
7	31.22	83.92
8	33.42	87.26
9	34.63	90.00

Circle Center At X = 12.5 ; Y = 98.6 and Radius, 23.8

*** 1.557 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.50	74.95
3	16.43	75.71
4	20.12	77.25
5	23.42	79.51
6	26.20	82.39
7	28.34	85.77
8	29.75	89.51
9	29.83	90.00

Circle Center At X = 10.7 ; Y = 94.5 and Radius, 19.7

*** 1.557 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.45	74.39
3	16.44	74.76
4	20.22	76.06
5	23.58	78.23
6	26.32	81.15
7	28.28	84.64
8	29.34	88.49
9	29.39	90.00

Circle Center At X = 13.0 ; Y = 90.9 and Radius, 16.6

*** 1.565 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.46	74.43
3	16.44	74.76
4	20.25	76.00
5	23.67	78.07
6	26.54	80.86
7	28.69	84.23
8	30.03	88.00
9	30.25	90.00

Circle Center At X = 13.0 ; Y = 91.9 and Radius, 17.5

*** 1.570 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.45	74.40
3	16.45	74.67
4	20.28	75.80
5	23.78	77.74
6	26.78	80.39
7	29.12	83.63
8	30.71	87.30
9	31.23	90.00

Circle Center At X = 13.2 ; Y = 92.7 and Radius, 18.3

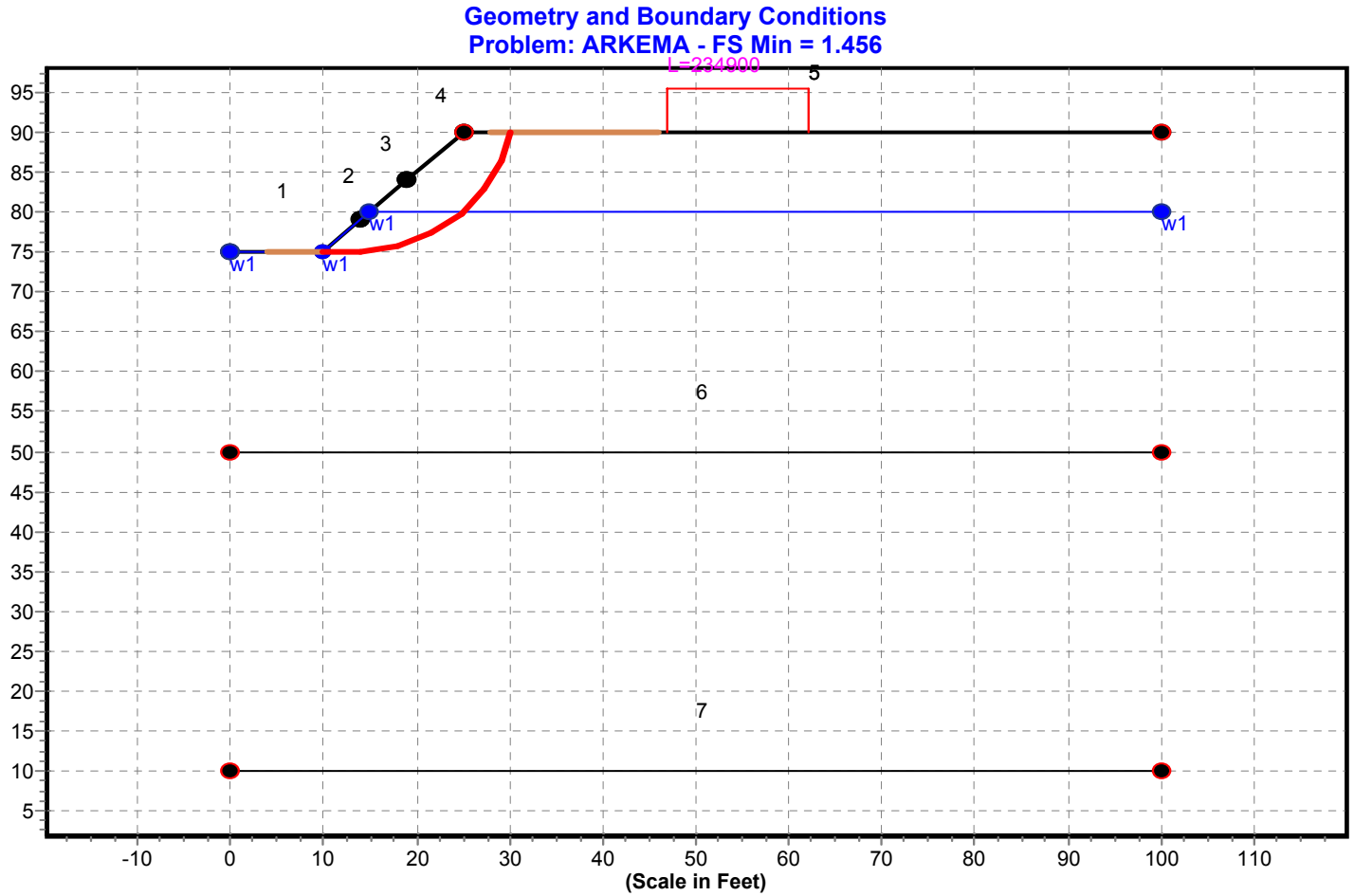
*** 1.585 ***

Failure Surface Specified By 9 Coordinate Points

| Point No. | X-Surf (ft) | Y-Surf (ft) |

```
    1          8.50       75.00
    2         12.47       74.51
    3         16.46       74.81
    4         20.31       75.89
    5         23.87       77.71
    6         27.00       80.19
    7         29.59       83.25
    8         31.51       86.75
    9         32.53       90.00

Circle Center At X =   13.0 ; Y =   94.7  and Radius,   20.2


      ***     1.598   ***



1

                Y            A     X     I     S            F     T


                0.00     21.06     42.13     63.19     84.26    105.32

X       0.00 +----*----+---------+---*-----+-----*---+---------+
             -                                     .
             -                                    .4
             -                                   ..*
             -                                   .21 *
             -                                   .71   *
       21.06 +                                   ..21.
             -                                   ...314   *
             -                                   ....517142
             -                                    .....3931
             -                                     .....5.5
             -                                      .......
A      42.13 +                                        .....
             -                                           .../1
             -
             -
             -
             -
X      63.19 +                                              1/
             -
             -
             -
             -
             -
I      84.26 +
             -
             -
             -
             -    *                   *             W    *
             -
S     105.32 +
             -
             -
             -
             -
             -
      126.38 +
             -
```

```
                -
                -
                -
                -
F     147.45 +
                -
                -
                -
                -
                -
T     168.51 +
```


Geometry and Boundary Conditions
Problem: ARKEMA - FS Min = 1.456
L=234900
1
2
3
4
5
6
7
w1
w1
w1
w1
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
-10
0
10
20
30
40
50
60
70
80
90
100
110
(Scale in Feet)

** PCSTABL6 **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: ENGLISH
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION ARKEMA RD

BOUNDARY COORDINATES

5 Top Boundaries
7 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	75.00	10.00	75.00	3
2	10.00	75.00	14.00	79.00	1
3	14.00	79.00	19.00	84.00	1
4	19.00	84.00	25.00	90.00	1
5	25.00	90.00	100.00	90.00	1
6	0.00	50.00	100.00	50.00	2
7	0.00	10.00	100.00	10.00	3

1

ISOTROPIC SOIL PARAMETERS

3 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	114.7	118.5	180.0	29.0	0.00	0.0	1
2	118.5	118.5	416.0	22.0	0.00	0.0	1
3	123.1	123.1	478.4	28.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	75.00
2	10.00	75.00
3	15.00	80.00
4	100.00	80.00

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

250 Trial Surfaces Have Been Generated.

50 Surfaces Initiate From Each Of 5 Points Equally Spaced Along The Ground Surface Between X = 4.00 ft.
and X = 10.00 ft.

Each Surface Terminates Between X = 32.00 ft.
and X = 44.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00 ft.

4.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -25.0 And 0.0 deg.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 9 Coordinate Points

Point	X-Surf	Y-Surf

No.	(ft)	(ft)
1	10.00	75.00
2	14.00	74.94
3	17.95	75.58
4	21.72	76.91
5	25.20	78.88
6	28.28	81.43
7	30.87	84.48
8	32.87	87.95
9	33.62	90.00

Circle Center At X = 12.3 ; Y = 97.5 and Radius, 22.7

*** 1.525 ***

Individual data on the 12 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	4.0	954.7	0.0	380.1	0.0	0.0	0.0	0.0	0.0
2	1.0	526.6	0.0	212.4	0.0	0.0	0.0	0.0	0.0
3	2.9	2125.8	0.0	868.2	0.0	0.0	0.0	0.0	0.0
4	1.1	946.9	0.0	294.6	0.0	0.0	0.0	0.0	0.0
5	2.7	2824.6	0.0	642.6	0.0	0.0	0.0	0.0	0.0
6	3.3	3984.6	0.0	508.6	0.0	0.0	0.0	0.0	0.0
7	0.2	260.7	0.0	17.1	0.0	0.0	0.0	0.0	0.0
8	1.4	1642.0	0.0	61.5	0.0	0.0	0.0	0.0	0.0
9	1.7	1839.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	2.6	2086.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	2.0	871.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.7	88.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.48	74.59
3	16.46	74.95
4	20.30	76.07
5	23.86	77.90
6	27.00	80.38
7	29.60	83.42
8	31.58	86.90
9	32.61	90.00

Circle Center At X = 12.6 ; Y = 95.4 and Radius, 20.8

*** 1.594 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.48	74.58
3	16.46	74.92
4	20.31	76.02
5	23.88	77.83
6	27.04	80.28
7	29.67	83.29
8	31.68	86.75
9	32.82	90.00

Circle Center At X = 12.7 ; Y = 95.5 and Radius, 20.9

*** 1.599 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.50	74.95
3	16.45	75.55
4	20.26	76.79
5	23.81	78.62
6	27.02	81.01
7	29.80	83.88
8	32.08	87.17
9	33.42	90.00

Circle Center At X = 10.8 ; Y = 99.5 and Radius, 24.6

*** 1.605 ***

1

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.43	74.24
3	16.43	74.35
4	20.31	75.32
5	23.89	77.10
6	27.00	79.61

7	29.50	82.74
8	31.26	86.33
9	32.15	90.00

Circle Center At X = 13.9 ; Y = 92.6 and Radius, 18.4

*** 1.616 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.45	74.39
3	16.45	74.58
4	20.33	75.55
5	23.94	77.27
6	27.14	79.67
7	29.81	82.65
8	31.84	86.10
9	33.14	89.88
10	33.16	90.00

Circle Center At X = 13.5 ; Y = 94.5 and Radius, 20.2

*** 1.619 ***

1

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	14.00	74.91
3	17.97	75.41
4	21.81	76.51
5	25.45	78.17
6	28.80	80.35
7	31.79	83.01
8	34.34	86.09
9	36.41	89.52
10	36.61	90.00

Circle Center At X = 12.6 ; Y = 101.4 and Radius, 26.6

*** 1.620 ***

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.46	74.43
3	16.45	74.61
4	20.34	75.55
5	23.99	77.20
6	27.25	79.51
7	30.02	82.40
8	32.19	85.76
9	33.68	89.47
10	33.79	90.00

Circle Center At X = 13.5 ; Y = 95.4 and Radius, 21.0

*** 1.629 ***

1

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.50	75.00
2	12.39	74.06
3	16.39	74.00
4	20.30	74.85
5	23.92	76.54
6	27.07	79.00
7	29.60	82.10
8	31.37	85.69
9	32.29	89.58
10	32.29	90.00

Circle Center At X = 14.6 ; Y = 91.7 and Radius, 17.7

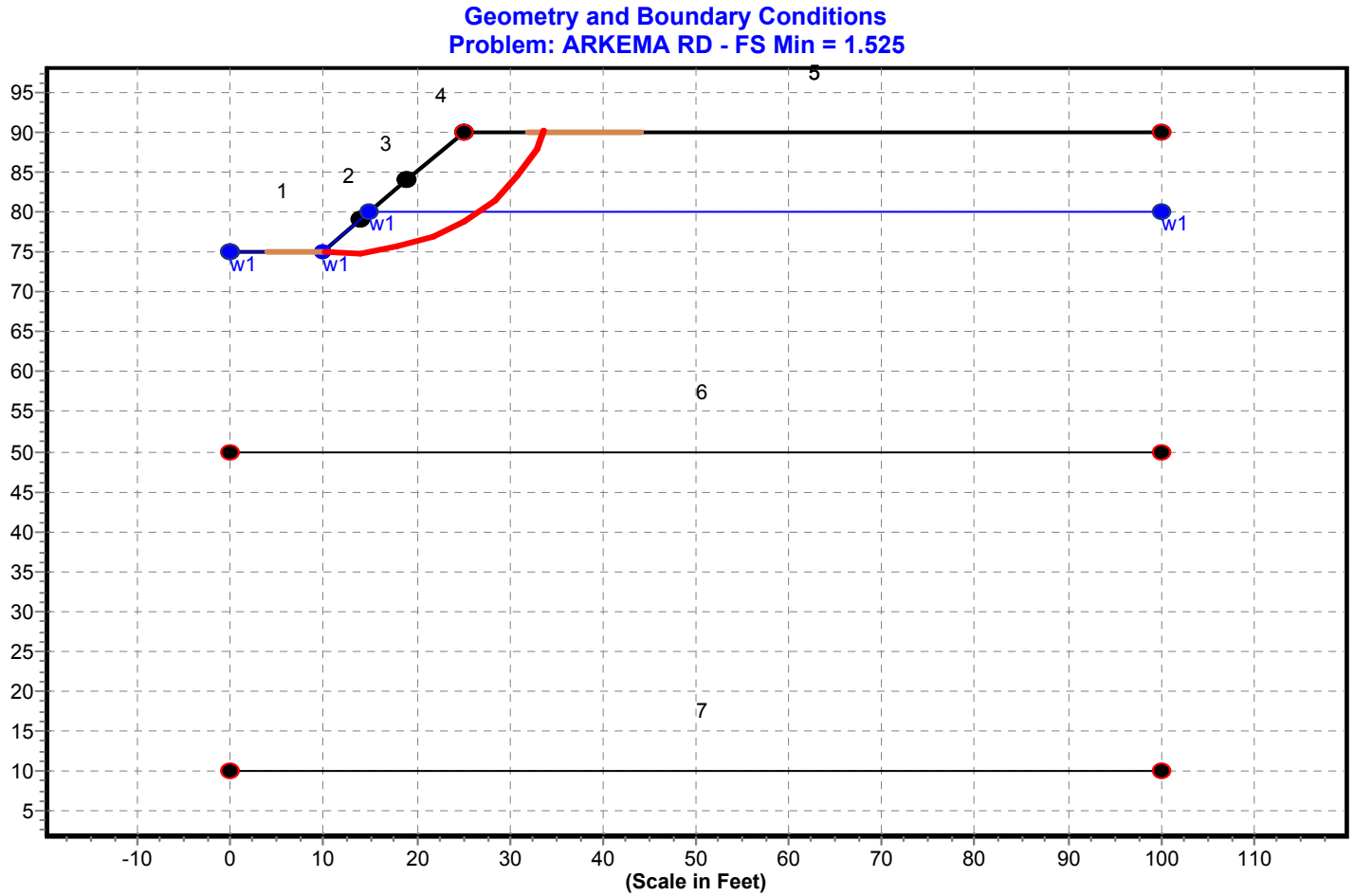
*** 1.642 ***

Failure Surface Specified By 9 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.00	75.00
2	13.90	74.09
3	17.90	74.09
4	21.79	75.00
5	25.38	76.77
6	28.47	79.31

```
    7         30.90       82.49
    8         32.55       86.13
    9         33.31       90.00

Circle Center At X =   15.9 ; Y =   91.5  and Radius,   17.5


      ***     1.645   ***



1

            Y            A     X     I     S            F     T


            0.00     19.80     39.60     59.40     79.20     99.00

X      0.00 +----*----+---------+----*----+-------*-+---------+
            -                                       .
            -                                      ..
            -                                    ..*
            -                                    .51 *
            -                                    .91.W
      19.80 +                                    ..24  *
            -                                    ..014.
            -                                     ..712.  *
            -                                     ...01215
            -                                      ....7611
            -                                       ......7
A     39.60 +                                        ......
            -                                          ....
            -
            -
            -
            -
X     59.40 +
            -
            -
            -
            -
            -
I     79.20 +
            -
            -
            -
            -
            -
S     99.00 +    *                    *             W    *
            -
            -
            -
            -
            -
     118.80 +
            -
            -
            -
            -
            -
F    138.60 +
            -
            -
```

```
                -
                -
                -
T     158.40 +
```


Geometry and Boundary Conditions
Problem: ARKEMA RD - FS Min = 1.525
1
2
3
4
5
6
7
w1
w1
w1
w1
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
-10
0
10
20
30
40
50
60
70
80
90
100
110
(Scale in Feet)