APPLICATIONS OF DOE'S GROUNDWATER RESTORATION STRATEGY FOR CLOSURE OF AN ARMY INSTALLATION

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INTRODUCTION

In 2001, the U.S. Department of Energy (DOE) developed and released its strategy for restoration of contaminated ground water at sites for which it held responsibility for contaminant releases. The strategy was previewed at "Waste Management 01" and subsequently underwent a review by the Interstate and Tribal Regulatory Council. The final version represents a consensus among the Department and regulators, and was released in 2002. Since that time various portions of the strategy have been applied to move forward with restoration of ground water and closure of contaminated sites. This paper describes two applications of the strategy to the same Department of Army site, Camp Bonneville, that is undergoing closure and transfer pursuant to Base Realignment and Closure Program initiatives. In the first application, the strategy was used to formulate the overall work plan for the facility, while in the second it was used to develop the groundwater monitoring plan.

The groundwater restoration strategy is based on risk-prioritized actions designed to meet the programmatic expectations of the U. S. Environmental Protection Agency (EPA). Based on risk considerations, initial attention is directed to identification and management of all imminent risk. Once all parties at risk have been protected against current risk, attention is turned to source removal and plume containment. When all practicable measures have been identified to control primary sources and contain the plume, resources are focused on restoration of water quality to its highest beneficial use. It is common for the work to be planned and executed in a phased fashion. Specific steps in the process are depicted in Figures 1 through 4and include:

1. Evaluating and mitigating any ongoing endangerment to public health or the environment;
2. Controlling residual source materials;
3. Containing the plume; and
4. Restoring the ground water to a quality that supports its highest beneficial use.

BACKGROUND

The groundwater restoration process has been applied to Camp Bonneville, a closed Army installation, as a means of supporting the ultimate cleanup and transfer of property. Camp Bonneville is comprised of approximately 3,840-acres and is located in southwestern Washington, approximately 10 miles outside of Vancouver. The Army used Camp Bonneville for live fire of small arms, assault weapons, artillery, and field and air defense artillery between 1910 and 1995. A portion of the property (840 acres) is leased from the State of Washington. The facility has been used for weekend and summer training by the U.S. Army Reserve units in Southern Washington and Northern Oregon. Camp Bonneville was included on the 1995 (BRAC) list, and the majority of Camp Bonneville will be transferred to a third party, possibly

Clark County under a public benefit conveyance for education, law enforcement, and parks. Specific areas that hosted activities that may have released contaminants on the installation included, landfills, ordnance disposal and burn areas, and live fire ranges.

In concert with the BRAC process, Camp Bonneville has been the subject of extensive studies and actions designed to prepare it for transfer to other parties. As a result of records research and environmental characterization (both soil and ground water) performed at the Installation, it has been determined that releases of chemicals have occurred at one disposal area in such a manner as to introduce contaminants into ground water at levels in excess of maximum contaminant limits (MCL). Releases are likely to have occurred in the large range areas as well, but their size and the nature of live fire training complicates the characterization necessary to determine if releases have negatively impacted ground water.

Application

Camp Bonneville posed a number of challenges to the restoration program. The former firing ranges cover an extensive portion of the installation in rugged terrain that is now covered with large conifers. In the case of the single known incidence of groundwater contamination, the presence of unexploded ordnance (UXO) complicated the investigation. With a clear mandate to transfer the property, the Army needed to find a means of expediting the restoration process without jeopardizing protectiveness. The groundwater restoration strategy was determined to be an effective means of achieving that objective.

The groundwater restoration strategy was applied by moving through each decision chain (Figures 1-4) with available data from the site. When data were not available, work plans were developed to obtain the missing information and proceed. The results of this dynamic process are discussed for each major element of the strategy in the following sections.

Address Current or Imminent Risk

At the time the strategy was implemented, there was a single site where groundwater contamination had been confirmed, Landfill 4. In response to the discovery, the public voiced a significant concern that affected water was migrating through bedrock and into drinking water supply aquifers in the area. Local landowners also expressed concern that other, untested areas, had contamination that was migrating unchecked. It was these concerns that the strategy was designed to address in the first stage of implementation.

The highest beneficial use of the aquifer at Landfill 4 appears to be its service as a source of water for Lacamas Creek. The surface waters may recharge deeper aquifers that would have the potential to be potable supplies, but the surface aquifer itself is not a potable supply.

There are no water supply wells completed in the shallow aquifer near Landfill 4. Moreover, the Army maintains control of the installation and will convey it with institutional controls that prohibit use of the shallow aquifer for potable water. In addition, much of the aquifer may not meet minimum requirements as a source of potable water in the state of Washington. For one thing, wells need a minimum of 15 feet of soil cover above the aquifer to qualify for potable use.

In addition, Washington uses a minimum yield of 0.5 gpm to define a potable aquifer. Of the four wells completed at Landfill 4 with sufficient data to calculate yield, only one yielded water at a rate above the threshold value. However, the public concern and the lack of definitive information on where the affected ground water discharged, made it important to assume there could be a pathway to potable water and attempt to determine if the concentrations of contaminant observed at Landfill 4 could pose an unacceptable risk if a pathway did exist.

Interpretation of initial potentiometric head data indicated that the plume from Landfill 4 is moving in westerly and southwesterly directions towards Lacamas Creek. (There has been some indication that at the northern edge of the plume, some water may separate and flow northward, but flow in that direction appears to result in discharge to the adjacent wetland that subsequently drains into Lacamas Creek. Hence, if there is a bifurcation of flow, it does not change the destination of the water, only its route.)

During the interpretation of the early data, it was deemed likely that all ground water discharges to Lacamas Creek. Furthermore, based on topography and the regional geologic fabric, it is likely that ground water that does not discharge into the creek turns and flows beneath and parallel to the streambed. As a consequence, were the plume to move off the installation, it would do so where Lacamas Creek exits the installation. However, potentiometric head data from wells completed in the deeper strata at Demolition Area #3 near the outlet of Lacamas Creek from the installation demonstrated significant artesian pressure indicating that if the surface aquifer at Landfill 4 did not daylight near the landfill, it likely would before migrating off site. Subsequently, two wells were installed near the outlet where the creek enters the broader valley in the center of the installation. These wells encountered competent bedrock within a few feet of the surface and verified that ground water discharges into the creek well in advance of where the creek exits the installation.

Based on drilling logs developed during recent monitoring well installation activities in this region, as well as those from previous studies at Landfill 4, much of Camp Bonneville consists of a surface alluvium overlying weathered and then competent bedrock. The surface alluvium is comprised of silty and sandy clays, while the weathered bedrock has rock fragments infilled with sandy and gravelly clay. The Troutdale Formation is encountered at the western boundary of the installation where the surface alluvium thins and disappears. The Troutdale is characterized as having clean gravel and cobble with much higher permeability than the surface alluvium it replaces.

Off-site water is drawn from the Troutdale Formation. Wells have been completed in both the surface aquifer and the Troutdale near the western boundary of Camp Bonneville where Lacamas Creek exits the installation. Samples taken from these wells have not been found to have any sign of contamination to date. Moreover, private wells located near the installation in the down-gradient areas have been sampled and found to be free of any contamination from the installation. Based on these findings, it was concluded that there is no current imminent risk of contact with contaminated water. Moreover, the installation boundary monitoring wells constitute a sentinel system that will provide early warning should any contamination migrate towards the installation boundary. However, residents remained skeptical about the potential for them to be impacted. As a consequence, a water balance was constructed for the watershed. The calculations revealed that stream flow accounted for all the surface runoff and recharge in the area, thus confirming the likelihood that there were no significant pathways for contaminated water other than Lacamas Creek. Moreover, the water balance clearly demonstrated that the dilution that occurs in the watershed (over 1,000 to one) provided extensive protection against a situation where concentrations leaving the installation could exceed maximum contamination limits (MCL). This analysis made it clear that even if a conduit was missed that would allow a plume to migrate off site, the plume would be too dilute to pose an unacceptable risk to human health.

Given the results of the water balance and the well logs, it is most likely that contaminated ground water from Landfill 4 is discharged to Lacamas Creek in the vicinity of the landfill. As such, the target concentrations for any restoration would be those associated with ambient water quality criteria. However, sampling in Lacamas Creek has not yielded any samples above the appropriate standards. This provides good empirical evidence that the dilution that occurs upon entry into the Creek is sufficient to prevent water quality problems from arising.

Given these findings, it is concluded that there is no current risk to human health and it is not likely there will be an unacceptable risk to human health in the future.

Evaluation of Source Control Measures

With the conclusion that no imminent risk existed, the focus turned to control of source materials causing the explosive and perchlorate contamination at Landfill 4. The area of the release was physically isolated on a shelf above Lacamas Creek and had been roughly bounded with geophyicals surveys and test pits. Because of the presence of UXO, the difficulty in distinguishing UXO from metal debris in the landfill, and the intent to transfer the property without long-term cap maintenance obligations, the Army decided to remove the waste materials and UXO.

Landfill 4 was excavated in the summer of 2004. Action levels were set to ensure that soil left after the excavation would not serve as a continuing source of groundwater contamination. During excavation it was observed that the primary source was not surface ordnance burning and ordnance disposal activities as originally thought, but discrete pits in which fireworks had been buried after incomplete burns were performed. The mystery as to why perchlorate had penetrated the fat clays so rapidly was resolved when at least one pit was found to have been dug to the saturated zone. With completion of the removal of soil to the selected action limits, the source has been controlled and conditions are no longer capable of producing groundwater contamination above the MCL.

Evaluation of Containment Measures

Based on the monitoring data available today and the water balance conducted at Landfill 4, it is clear that the extant plume will be contained naturally (the result of discharge to Lacamas Creek) before it can migrate off site. Hence, containment on site is guaranteed. What is not clear is the exact dimensions of the existing contamination and how far it will expand before it becomes stable and begins to recede. The most recent wells were installed a distance of roughly 500 yards south (directly down gradient) of the last well and have been found to have no detectable contamination (Figure 5). As such, the plume is bounded even if the exact limits are not known to within less than a few hundred feet. Given the distance of Landfill 4 from the installation boundary, the presence of multiple wells between Landfill 4 and the boundary, and the intent to prohibit potable use of groundwater on site in the future, no further precision is needed in defining the limits of the extant plume.

Evaluation of Restoration

Given that containment is likely in the near future as a result of dilution, that the source term has been removed, and that the aquifer properties (e.g., thin saturated zone, low hydraulic conductivity, difficult terrain, and significant heterogeneity) are not conducive to accelerated restoration, it does not appear likely that there is any clear advantage to pursuit of an active remedy for restoration of the ground water quality at this time. The cost would be high and there would be no measurable benefits since the water use (i.e., discharge to surface water) is not currently impaired and is not likely to ever be compromised by this plume. This tradeoff will be further articulated in an impending feasibility study.

By implementing the restoration strategy, it was possible to reduce the time and cost of investigation without sacrificing protectiveness. Moreover, the stage is set to avoid implementation of a costly remedy that will have little real benefit. The strategy resulted in a demonstration of no unacceptable risk and the strong likelihood that natural attenuation will restore the groundwater quality in an acceptable time frame. If monitored natural attenuation or a similar long-term monitoring remedy are selected as the final remedy, it will be necessary to monitor the plume until concentrations fall below MCLs. The cost of monitoring will be relatively small compared to those of an active remedy, but will mount if the plume persists for a long time. As a consequence, there is a need to develop a cost-effective monitoring program with a ramp-down schedule and decision rules to match the cost to the benefit.

Groundwater Monitoring Plan

The groundwater restoration strategy was also applied in principle to establish the long-term monitoring program for the installation as a whole. At the time the plan was developed, it addressed areas that were thought to have potential for contamination at the time. As such, it extended beyond Landfill 4. There were four primary objectives for ongoing and future groundwater monitoring at that time:

1. Discover any groundwater contamination arising from anthropogenic activities at the installation;
2. Determine the nature and extent of contamination that is identified;
3. Generate information necessary to evaluate remedy performance; and
4. Provide an early warning should any contamination pose a threat to water supply wells or surface waters on or off the installation.

Pursuant to findings to date and the overall objectives of the site characterization activities, 27 monitoring wells have been installed at Landfill 4 and the remaining study areas of the Installation as depicted in Figures 5-6.

Given the four objectives for the monitoring program and the Army's fiduciary responsibility to eliminate unnecessary spending, there was a need to develop and document a strategy that clearly defines the optimum location for wells; the type of data to be gathered from each well (i.e., the analytes); the frequency at which the data are to be collected; and the conditions under which activity can be stopped.

Location

In general, the 27 wells can be classified in one of three categories:

1. Source control wells – wells placed around known or suspected releases to detect the presence of a plume or to delineate the plume once it is detected;
2. Pathway wells – wells placed along a probable flow path as a means of determining that an otherwise undetected source must be present in the up-gradient area (in the case of release sites where the terrain is not amenable to installation of monitoring wells) or as a means of confirming that a known plume has not yet reached that portion of the pathway; and
3. Perimeter wells – wells placed to provide an early warning of any contamination that may be migrating off site as a result of known or unknown sources.

Accordingly, the location of wells was dictated by the location of activities known or thought to have released chemicals and the projected flow path of the ground water as determined during application of the restoration strategy.

Analytes

Initially, the designated analytes were the toxic chemicals list regulated by the state plus military specific compounds identified with the known site activities (i.e., explosives) as follows:

- Metals (total and dissolved),
- Volatiles,
- Semi-Volatiles,
- Petroleum Hydrocarbons,
- Explosives,
- Nitroglycerine (NG),
- Pentaerythritol tetranitrate(PETN),
- Picric Acid,
- Perchlorate,
- Water Quality Parameters (total organic carbon – TOC, dissolved organic carbon – DOC, total suspended solids – TSS, alkalinity, ionic species – chlorides, sulfates, nitrates)

The decision logic in Figures 7-9 will be applied to the appropriate well type as a means of paring the analytes down to those that have been demonstrated to be present in any given area.

In addition, the water quality parameters will be retained to provide a means of determining if there has been a significant change in geochemistry or if there is reason to challenge the notion that a sample is representative.

Because there are no source control wells at Demo Area #2, the decision logic in Figure 9 does not apply directly. At Demo Area #2, soil data will be evaluated to determine if a source exists. In particular, soil characterization data will be compared to criteria developed for Landfill #4 using the Model Toxic Control Act (MTCA) Level B approach for protection of groundwater quality. The most likely candidates are the explosive compounds for which the following criteria have been calculated:

- 2,4 Ditrotoluene – 0.5 ppm
- Perchlorate – 0.5 ppm
- HMX – 0.5 ppm
- RDX – 0.5 ppm

If a sample is observed to have any contaminant in excess of the associated groundwater protection criterion, the nature and extent of contaminant above the criterion will be determined to evaluate if groundwater quality is threatened. To the extent that any soil contamination above a criterion is left in place, the site will be treated as having an active source relative to the monitoring well decision logic.

Initial Frequency of Monitoring

All wells will be sampled for eight consecutive quarters. If any analyte is not observed for a continuous period of two years it will be dropped from future monitoring in that well.

Decisions to eliminate analytes, change the frequency of monitoring, and drop wells from the program will be made using the logic flow presented in Figures 7-9 for each well in each of the three well categories.

CONCLUSION

The groundwater restoration strategy was found to be an excellent framework for making decisions on investigation and remediation of contaminated ground water. It also facilitated development of a ground water monitoring plan for pre- and post-closure activities.

APPENDIX 1 – Figures

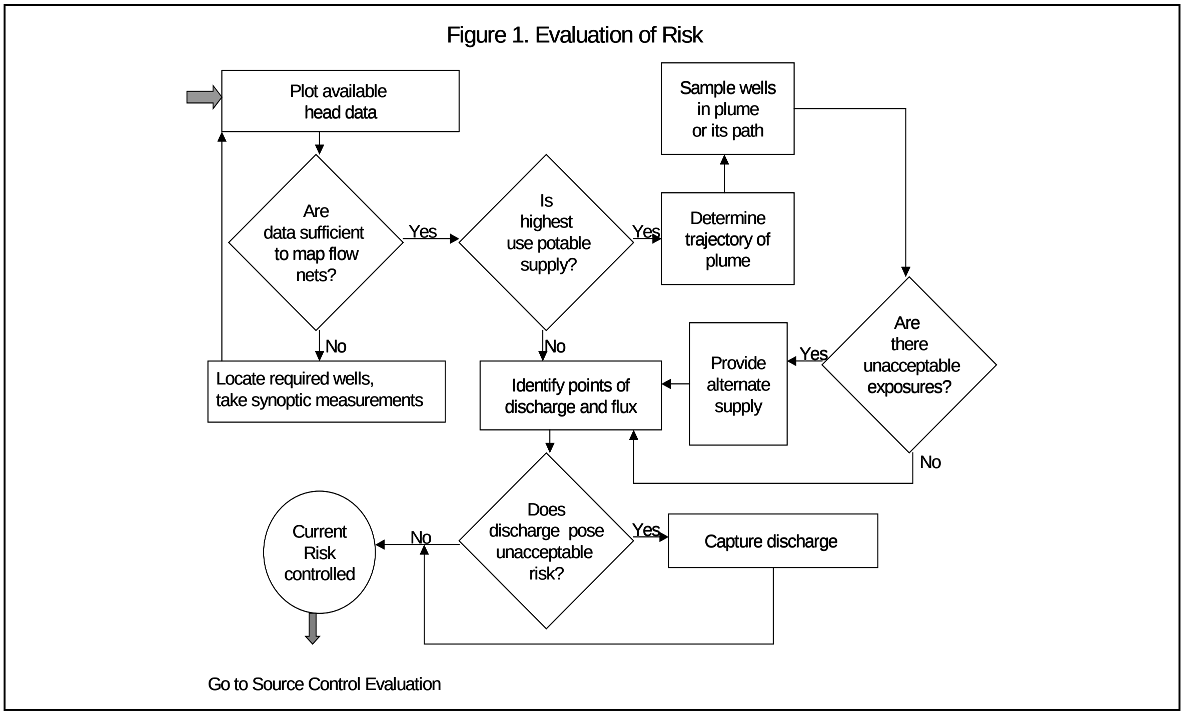

Fig. 1. Decision logic for evaluation of risk

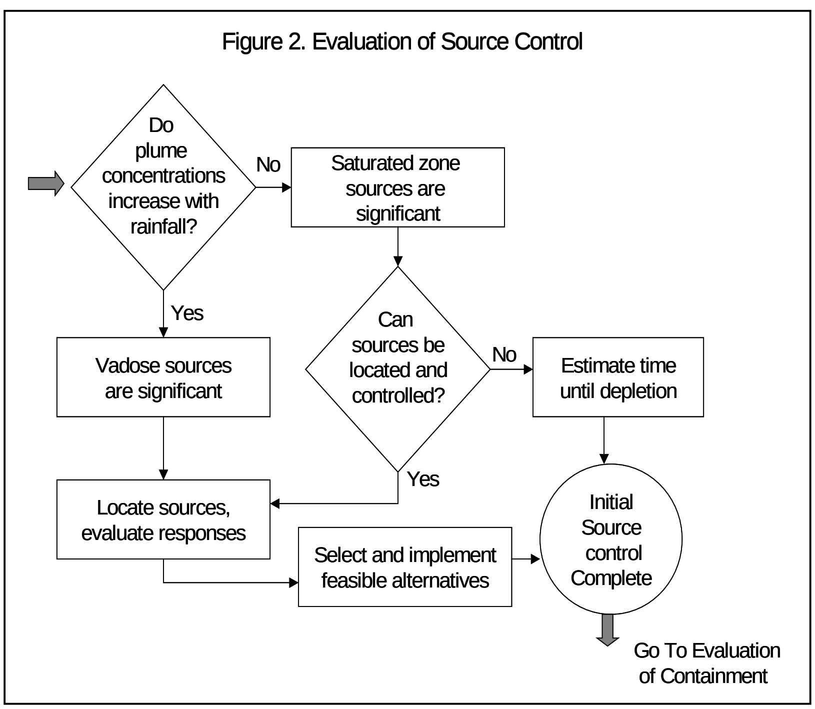

Fig. 2. Decision logic for evaluation of source control

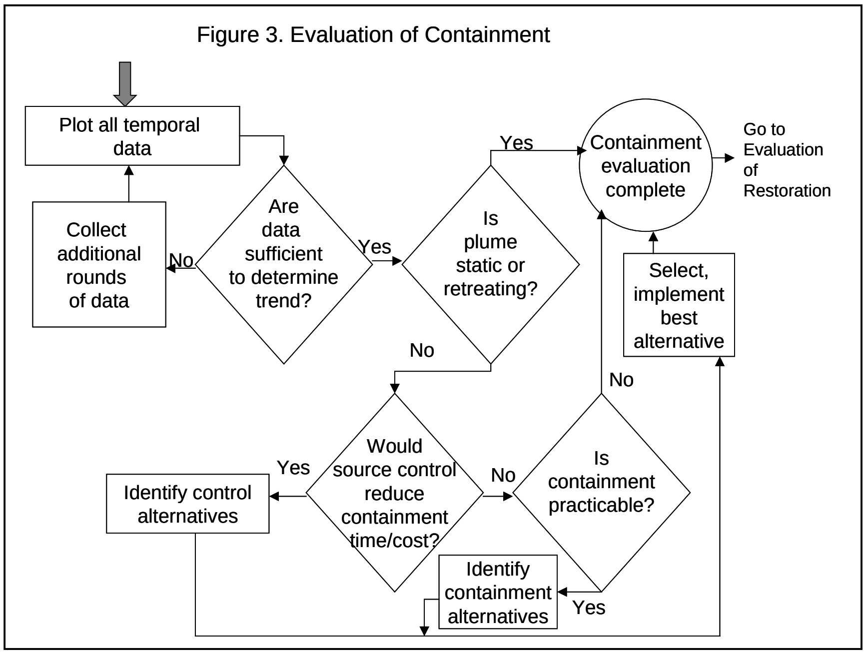

Fig. 3. Decision logic for evaluation of containment

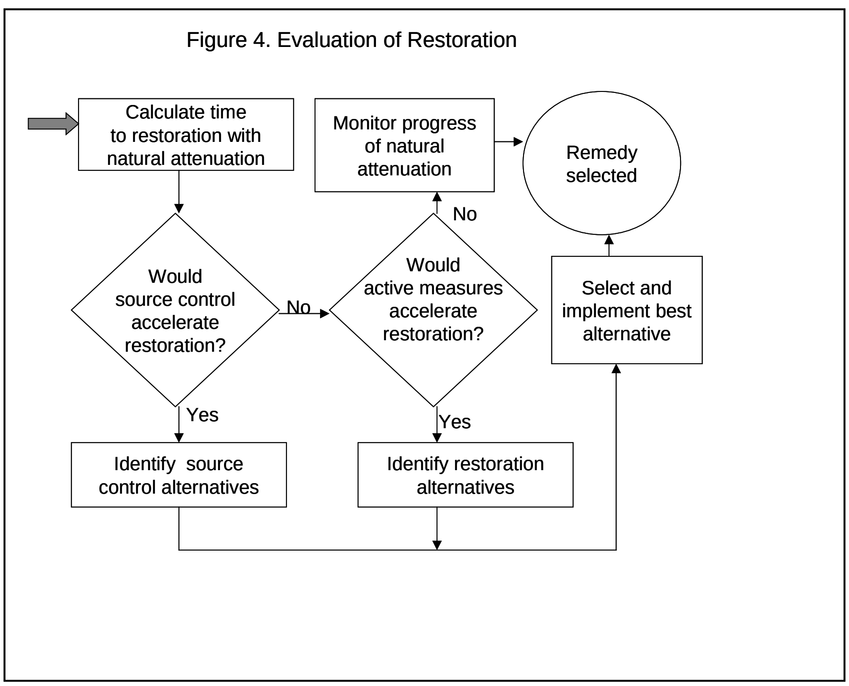

Fig. 4. Decision logic for evaluation of restoration

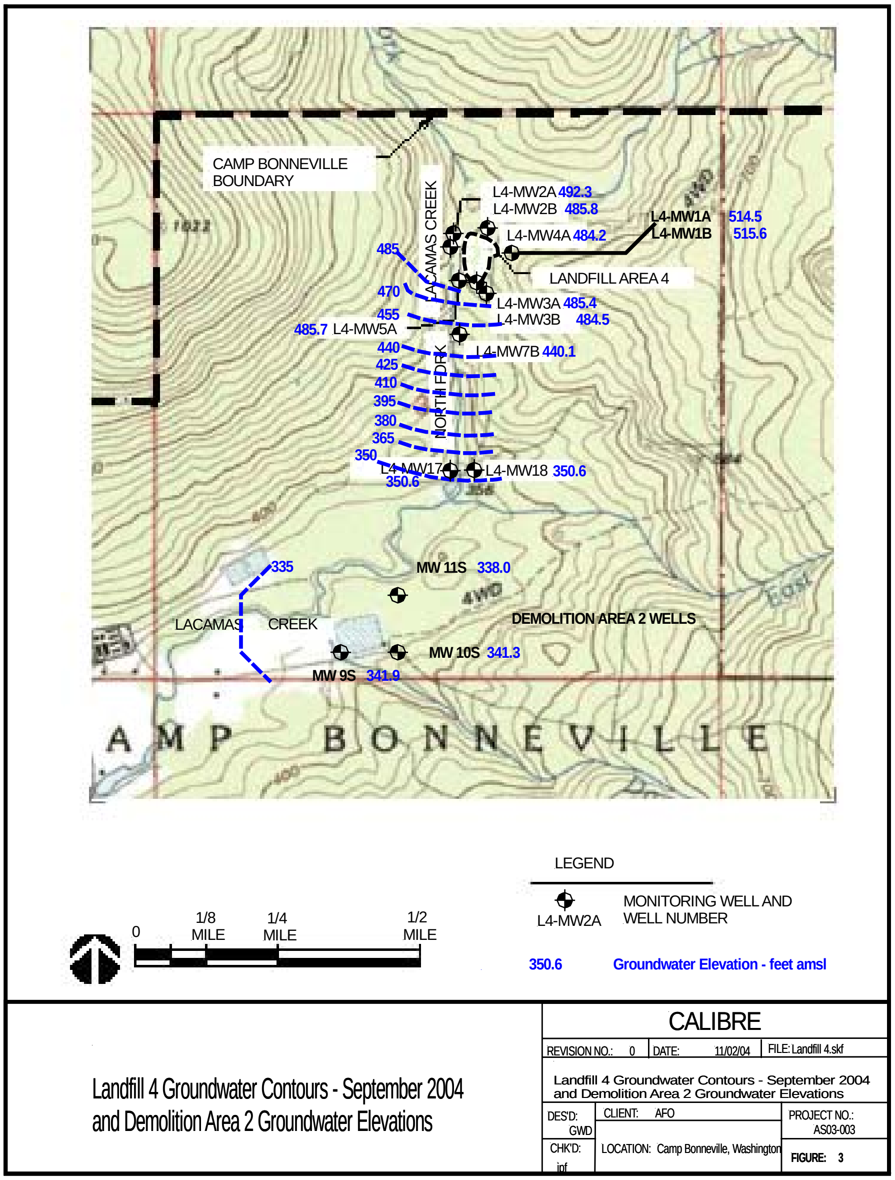

Fig. 5. Location of monitoring wells at Landfill 4.

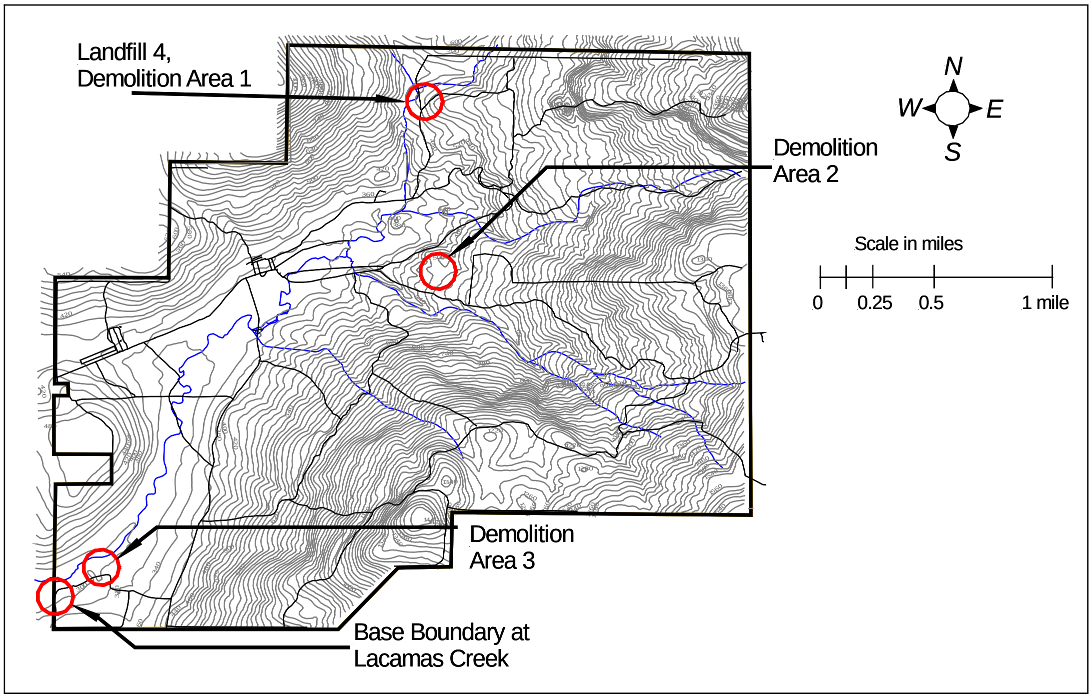

Fig. 6. Location of study areas at Camp Bonneville

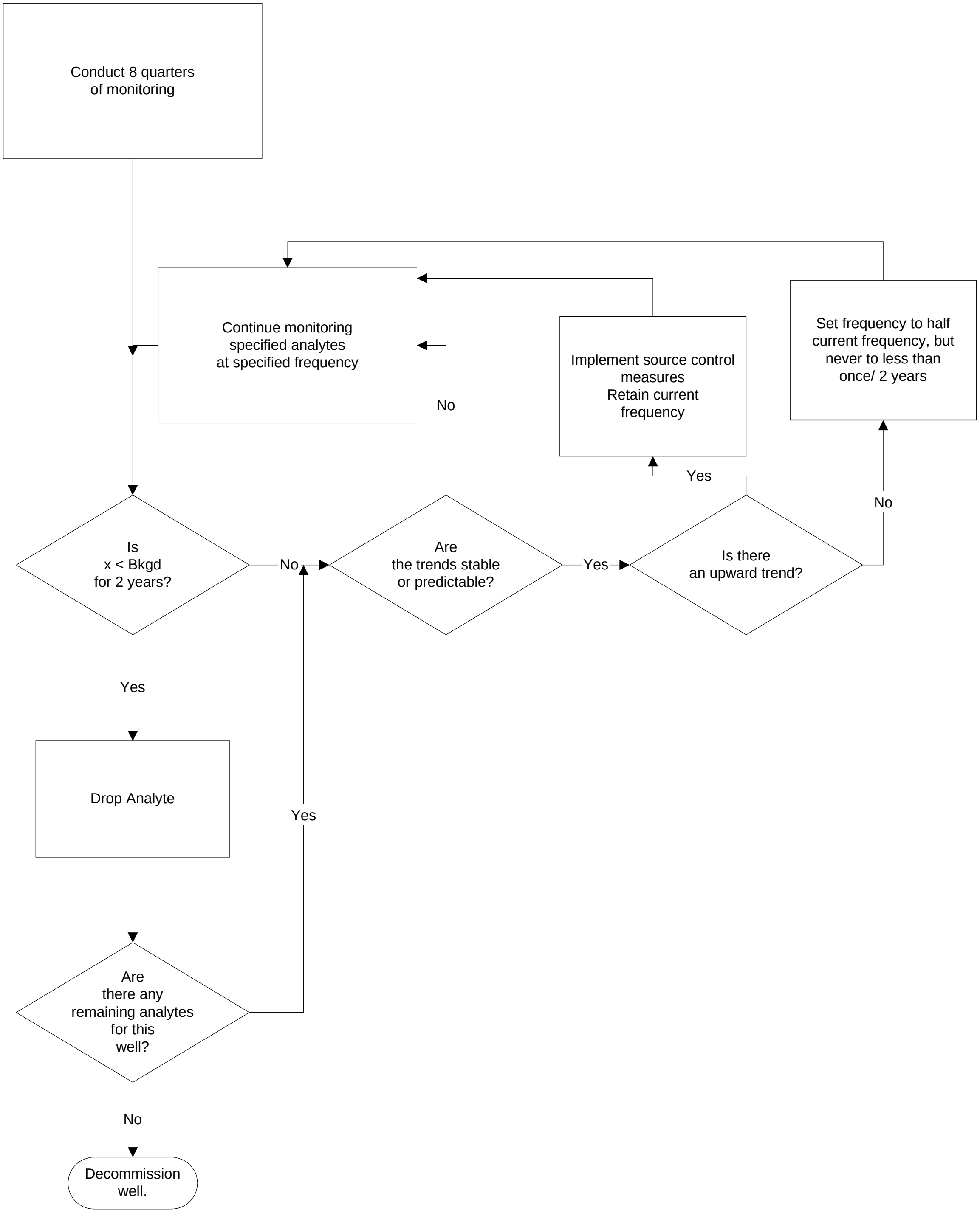

Fig. 7. Decision logic for operation of source control wells

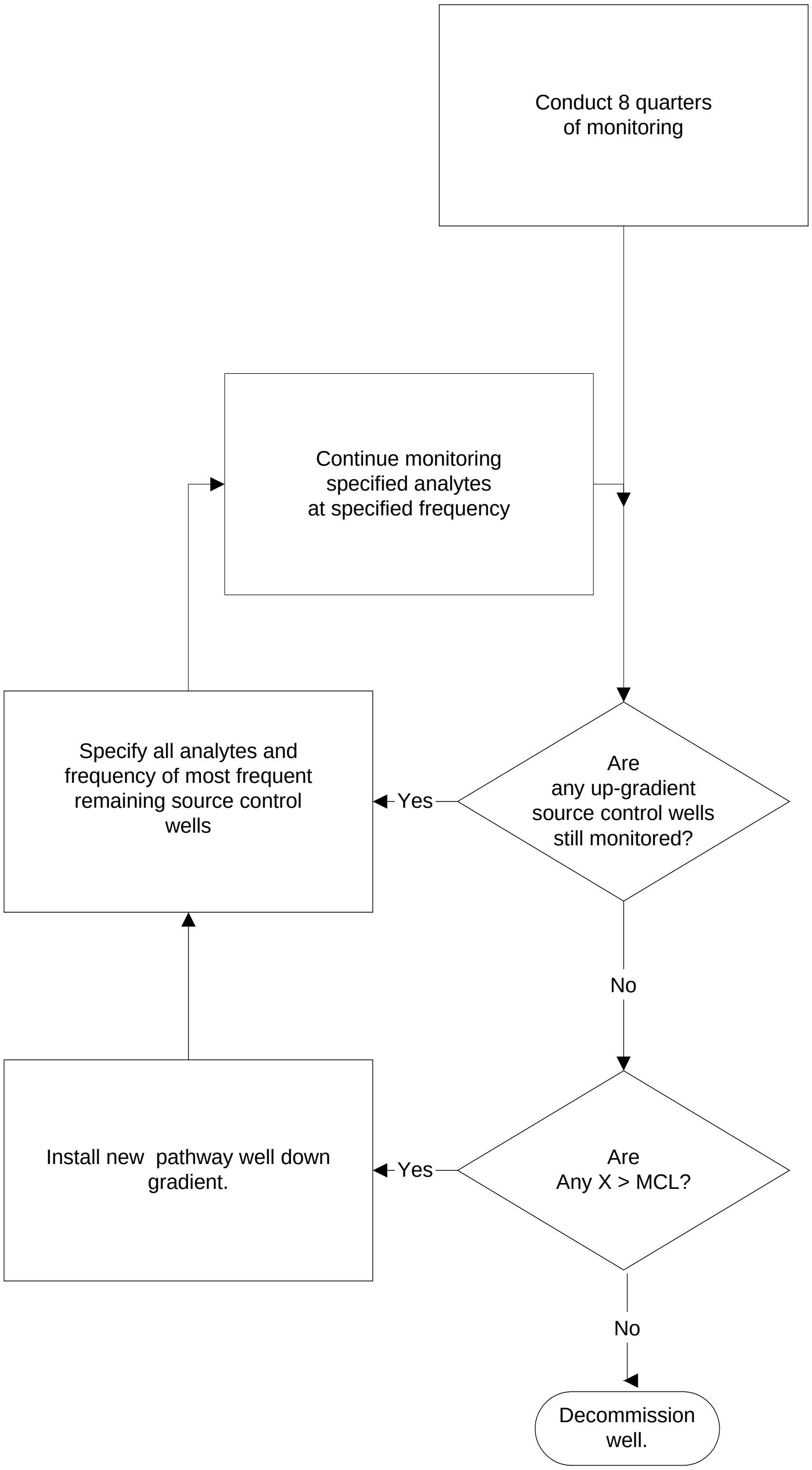

Fig. 8. Decision logic for operation of pathway wells

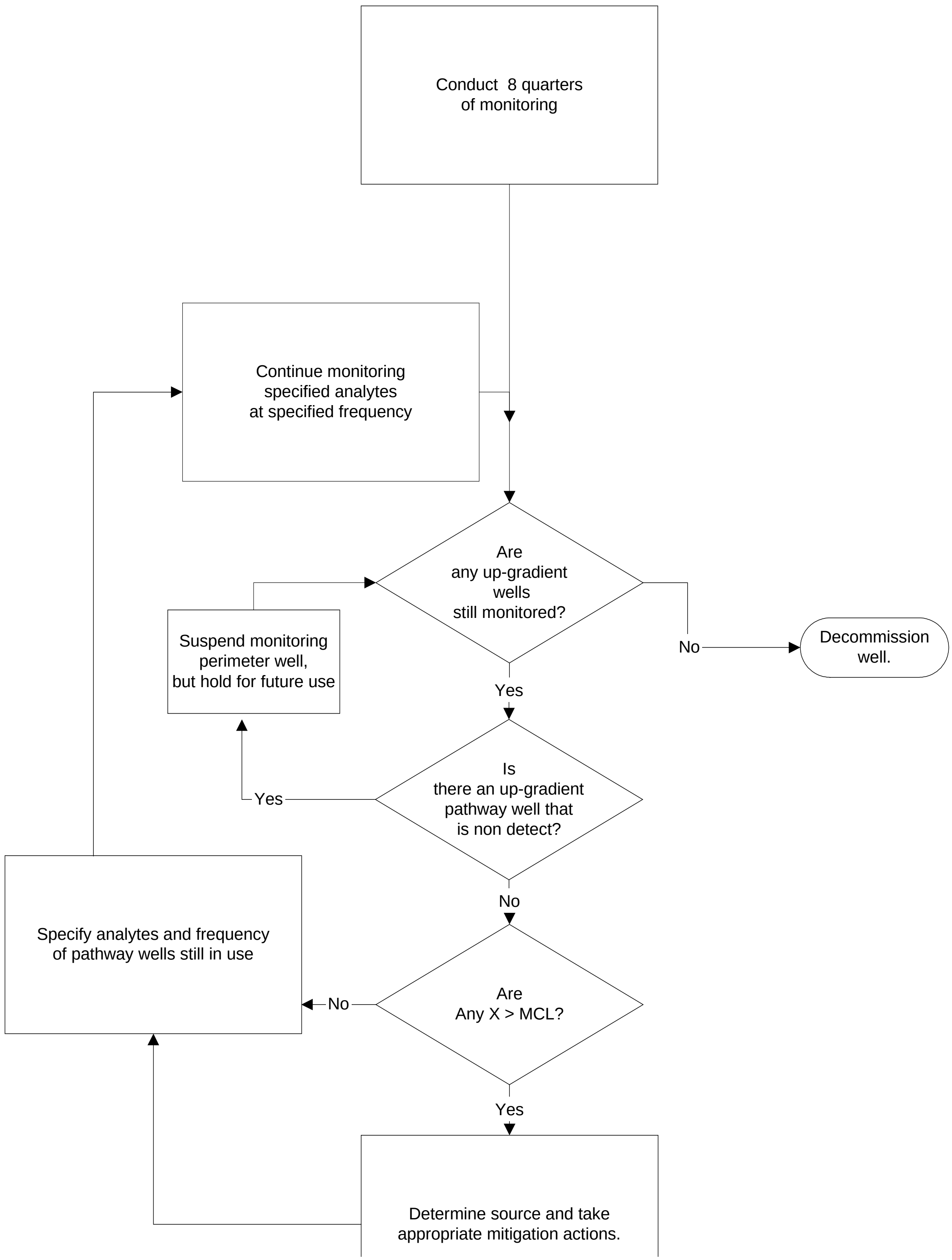

Fig. 9. Decision logic for operation of perimeter wells