RISK-BASED APPROACH TO PETROLEUM HYDROCARBON REMEDIATION

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1994

The risk-based approach (Figure 1) utilizes tools developed under the BTEX, Intrinsic Remediation (natural attenuation), Bioslurper, and Bioventing Initiatives of the Air Force Center for Environmental Excellence Technology Transfer Division (AFCEE/ERT) to construct a risk-based cost-effective approach (Figure 2) to the cleanup of petroleum contaminated sites. The AFCEE Remediation Matrix (Enclosure 1) identifies natural attenuation as the first remediation alternative for soil and ground water contaminated with petroleum hydrocarbons. The intrinsic remediation (natural attenuation) alternative requires a scientifically defensible risk assessment based on contaminant sources, pathways, and receptors. For fuel contaminated sites, the first step is to determine contaminants of interest. For the ground water pathway (usually considered most important by regulators), this will normally be the most soluble, mobile, and toxic compounds, namely benzene, toluene, ethyl benzene, and o, m, p, xylene (BTEX) (Figure 3).

Since BTEX is the contaminant of interest for the ground water pathway, then it follows that BTEX should be the focus in both soil and floating product. If there is no BTEX in the soil or in the floating product, then there is no source for BTEX contamination of the ground water and there is no risk-based reason to treat the soil or remove the floating product. However, the current regulatory environment encourages product removal and/or soil cleanup based on presence of liquid in monitoring wells or total petroleum hydrocarbon (TPH) analysis, respectively, regardless of BTEX content. The BTEX initiative is designed to promote cleanup based on a BTEX standard and we are collecting data to determine relative rates and costs of BTEX vs. TPH cleanup through the Bioventing Initiative.

Enclosure 2 is a tool to help Team Chiefs and base Remedial Project Managers (RPMs) better understand the TPH/BTEX issue and better negotiate cleanup based on a risk-based cleanup standard. One very important conclusion of the three documents combined under the title *Use of Risk-Based Standards for Cleanup of Petroleum Contaminated Soil* is that TPH is **appropriate only for screening** and **not appropriate as a cleanup standard**. Another conclusion is that state standards are most often action levels not cleanup levels and, in most states, an opportunity exists for negotiation based on risk. Enclosure 3, titled *State Summary of Soil and Ground water Cleanup Standards for Hydrocarbons*, is a good place to begin an evaluation of your state's flexibility with regards to cleanup levels.

If there is BTEX contamination in the ground water at a site, natural attenuation processes will likely destroy it prior to reaching a receptor. This may be the case even if a continuing source of BTEX is present in the soil and/or floating product. In this case an intrinsic remediation scenario based on modeling and long-term monitoring, possibly without soil cleanup or product removal, would be advocated (Figure 4).

The AFCEE/ERT Natural Attenuation Initiative (45 sites) is developing the methods, protocols, and regulatory awareness necessary to implement this responsible and cost-effective alternative across the DOD. To date, we have collected data at 10 sites in cooperation with EPA's Robert S. Kerr Environmental Research Laboratory (RSKERL) in Ada, OK, and our experience is being documented in Enclosure 4 titled *Technical Protocol for Implementing the Intrinsic Remediation with Long-Term Monitoring Option for Natural Attenuation of Dissolved-Phase Fuel Contamination in Ground Water.* Although in draft form, the document has gone through two peer reviews at RSKERL. We hope to finalize the appendices and case studies this year.

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It is important that team chiefs and RPMs pay immediate attention to Table 2.1 in the above named document because it specifies an analytical protocol necessary for evaluating the intrinsic remediation option. It is extremely important that any future remedial investigations consider including the parameters in Table 2.1 so that the intrinsic remediation option can be fairly evaluated against other conventional, costly, and often ineffective technologies (i.e., pump and treat). Enclosure 5 (*United States Air Force Guidelines for Successfully Supporting Intrinsic Remediation with an Example from Hill Air Force Base*) is a good summary of the protocol and a case study. A recent symposium co-sponsored by RSKERL, the US Geological Survey (USGS), and AFCEE provided an excellent forum for regulators and owners to discuss the science behind this emerging technology. Enclosure 6 is the proceedings of said conference (*Symposium on Intrinsic Bioremediation of Ground Water).*

If continuing sources of BTEX "overload" the assimilative (natural attenuation) capacity of the aquifer allowing unacceptable pathway and receptor completion, then the source needs to be reduced to below the assimilative capacity of the ground water. For instance, if floating product or contaminated soil is leaching BTEX at a rate too high to allow the natural attenuation alternative, then removal must be considered. Unfortunately, removal of floating product is often very costly and generally removes only a small fraction of the hydrocarbon that is a source of BTEX.

The AFCEE/ERT Bioslurper Initiative (26 sites) is designed to accomplish two goals. First, a protocol will be developed by comparing simple empirical methods for evaluating potential for product removal with actual product removal accomplished with the most aggressive vacuum-assisted product removal technique, bioslurping (Figure 5). Bases should then be able to apply the empirical techniques to evaluate potential for product removal at remaining sites. The goal is to avoid, in the future, the installation of expensive product removal systems when simple tests can confirm before hand that significant removal is unlikely. Second, for sites where significant product removal is possible, the bioslurper initiative will collect, at multiple sites, the necessary cost and performance data for comparison with conventional technologies. The bioslurper protocol is currently under development and a draft should be available by early 1995. Enclosure 7 is a fact sheet on this technology and Enclosure 8 is a case study titled *Bioslurping - Vacuum-Enhanced Free Product Recovery Coupled with Bioventing*. These enclosures will provide readers a good interim summary of this innovative technology while the protocols are being developed.

If petroleum contaminated soil is determined to overload the assimilative capacity of both the vadose zone and ground water, treatment must be considered (Figure 6). The AFCEE/ERT Bioventing Initiative (130 sites) has demonstrated the effectiveness of this technology ("tool") to preferentially destroy the risk-based BTEX compounds. Therefore, bioventing is particularly well suited for the risk-based approach. Also effective for the treatment of TPH (3-5 years), bioventing has been demonstrated to degrade BTEX to acceptable levels in as little as one year. Under a risk-based approach, bioventing should be initiated to target BTEX (not TPH) removal to the level that natural attenuation can effectively control the solubilized contaminant plume.

Several "tools" have been developed to assist in implementing bioventing when soil remediation is required. First, the *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing*, published in May 1992, has been widely distributed to bases and therefore is not included in this mailing. If you do not have a copy of this document, please contact AFCEE/ERT at (210) 536-4331 (DSN 240-4331) and we will send it to you. Second, *Addendum One To The Test Plan and Technical Protocol for a Field Treatability Test for Bioventing - Using Soil Gas Surveys to Determine Bioventing Feasibility and Natural Attenuation Potential* (Enclosure 9) will assist in determining when bioventing is or is not appropriate and how to determine if natural processes alone are providing remediation. Third, the *Bioventing Performance and Cost Summary, July 1994* (Enclosure 10), provides a good overview of the technology, initial results of the Air Force Bioventing Initiative, and cost data for bioventing and competing technologies.

The bioventing cost data is based on 130 sites and should be considered well documented. Fourth, *The Bioventing Procedures and Practices Manual* (design manual), a cooperative effort with EPA's Risk Reduction Engineering Laboratory (RREL) in Cincinnati, OH, is currently in draft stage with a final expected in December 1994.

In summary, the risk-based approach (Figure 7) establishes the capacity of natural processes to prevent receptor exposure through the ground water, which is the most common pathway of exposure. If continuing sources of BTEX (soil and product) exceed the assimilative capacity of the aquifer (soil, water, microorganisms, electron acceptors, etc.), remediation efforts should focus on reducing BTEX sources to the point that natural attenuation processes will reduce risk to acceptable levels. Numerous "tools" have been developed, and are being developed, to assist Team Chiefs and RPMs in building the risk-based approach "house" (Figure 8). The AFCEE/ERT Risk-Based Approach Initiative is testing this concept at fuel contaminated sites on five Air Force bases. A generic Engineering Evaluation/Cost Analysis (EE/CA) is being produced based on the experience gained at these contaminated sites. In addition, EE/CAs are being produced for each of the individual technologies that make up the risk-based approach.

It is hoped that Team Chiefs and RPMs will seriously consider this approach as a cost effective presumptive remedy for remediation of fuel contaminated sites. We believe that this approach satisfies our mandate to protect public health and the environment and, at the same time, be responsible stewards of the taxpayers' money. If you have any questions about this approach or the "tools" provided, please contact AFCEE/ERT at (210) 536-4331 or DSN 240-4331.

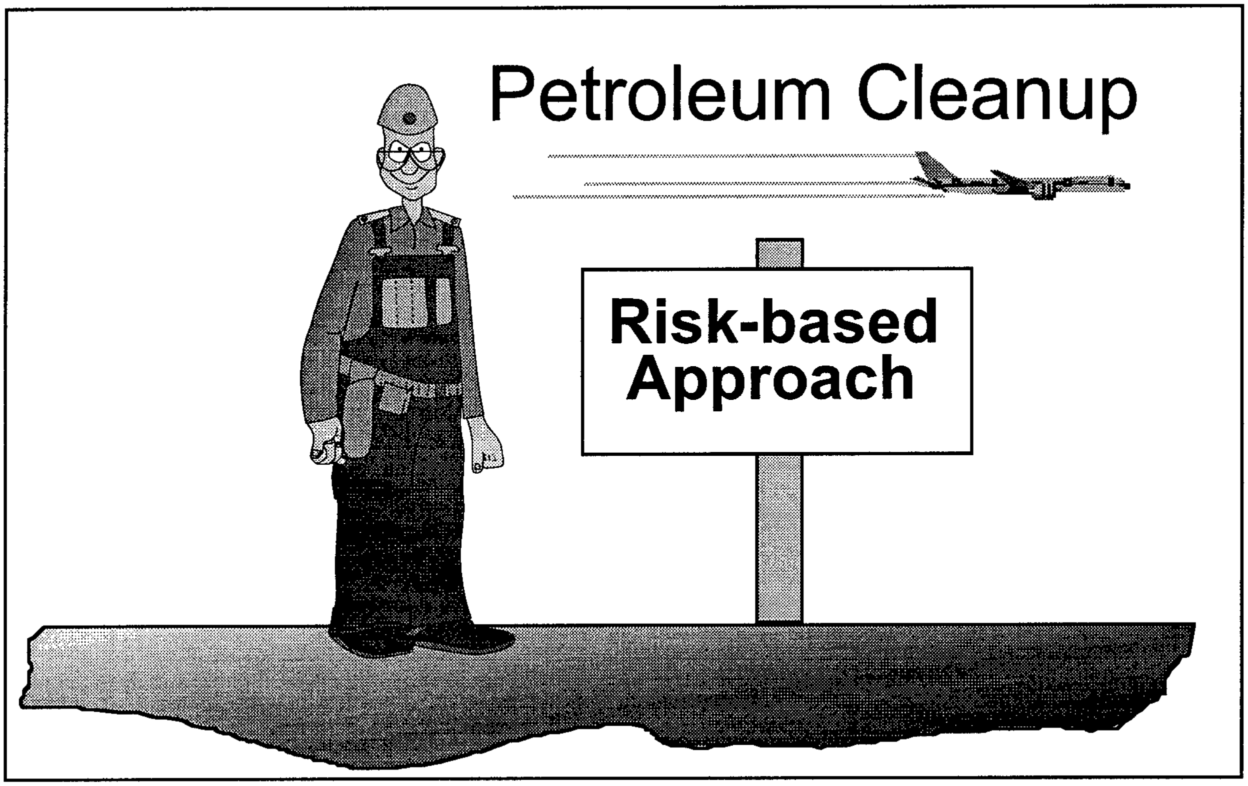


Figure 1

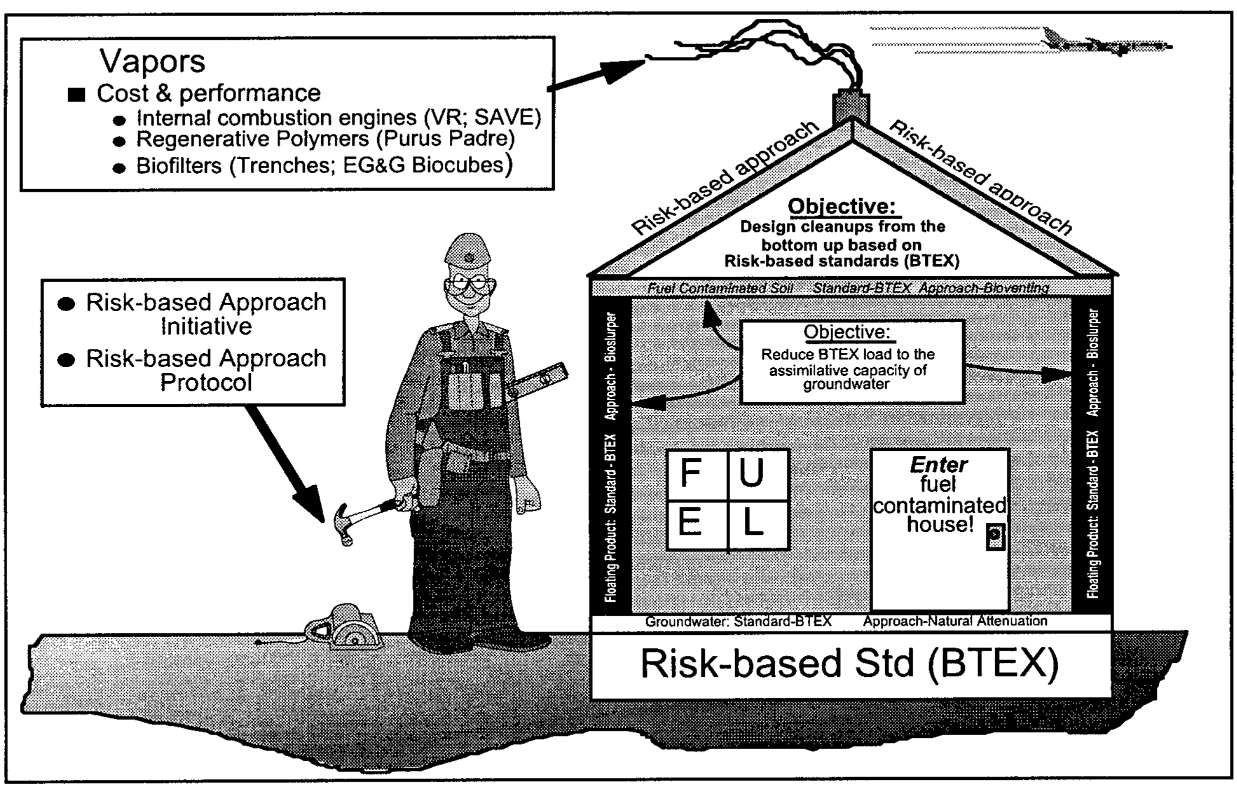


Figure 2

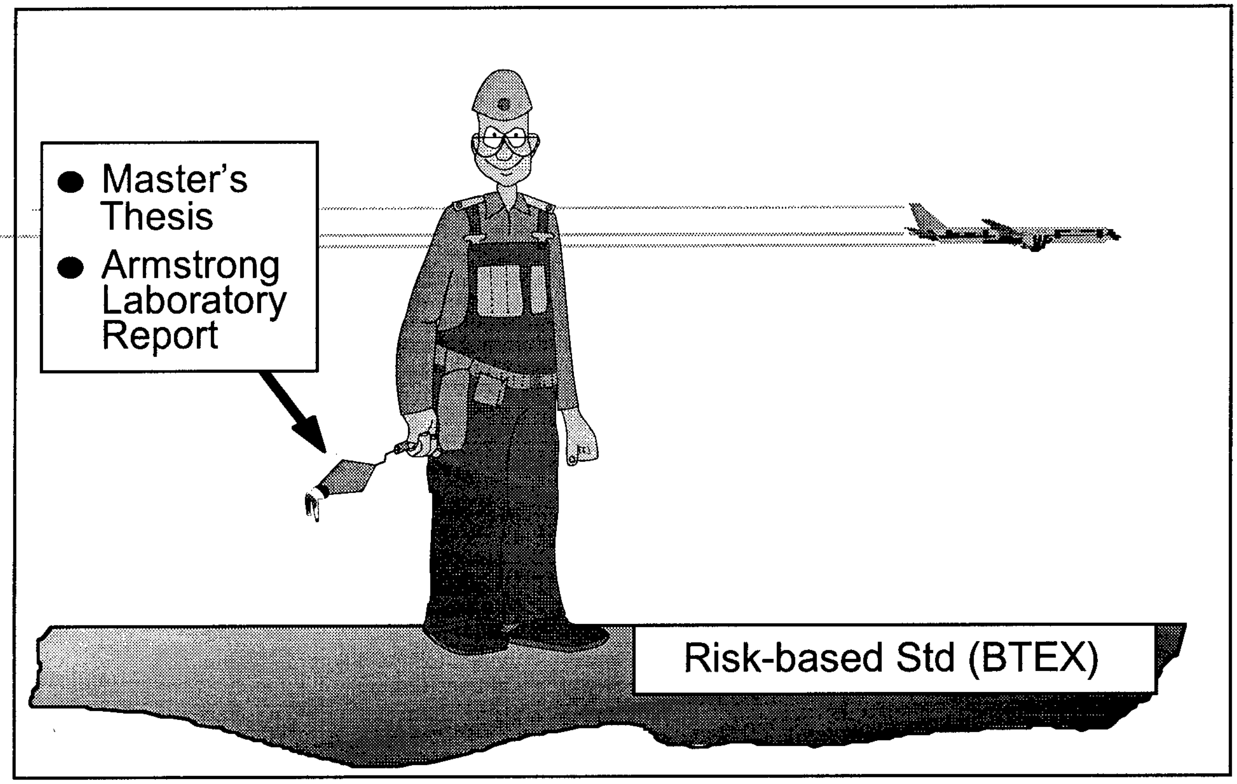


Figure 3

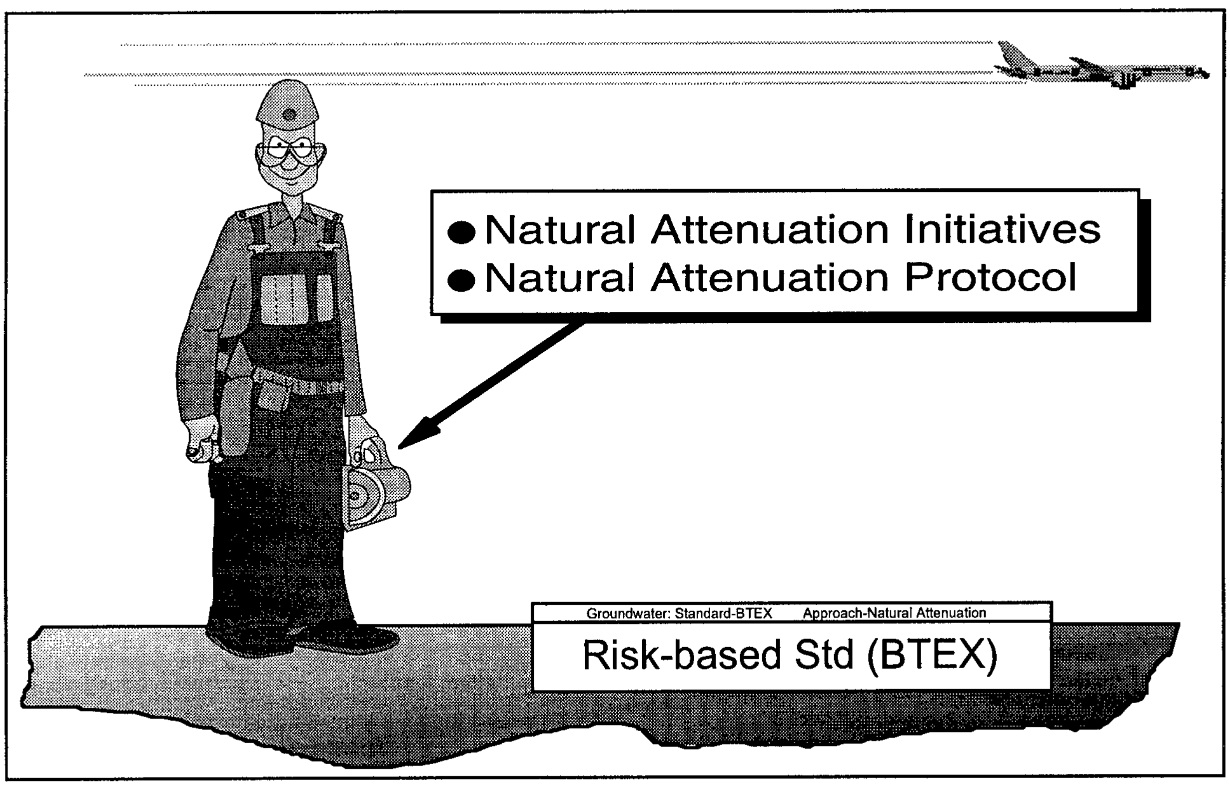
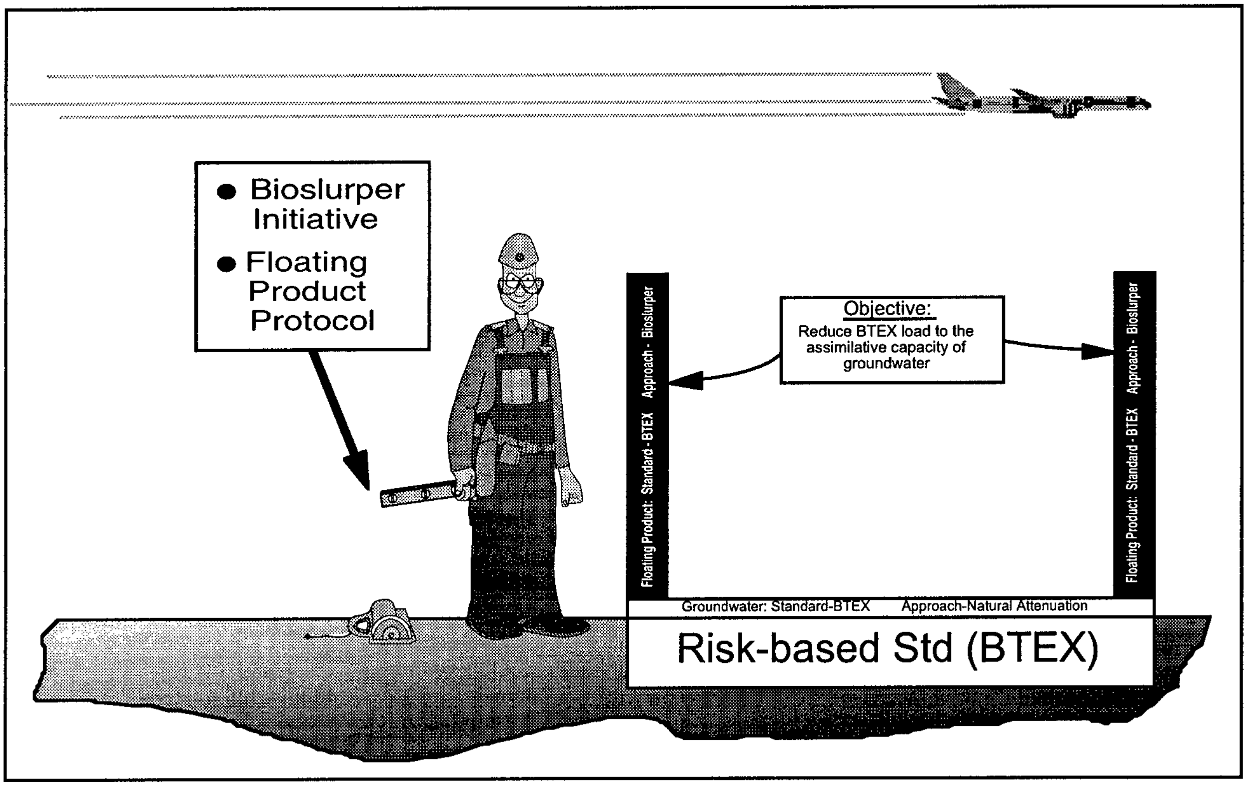


Figure 4



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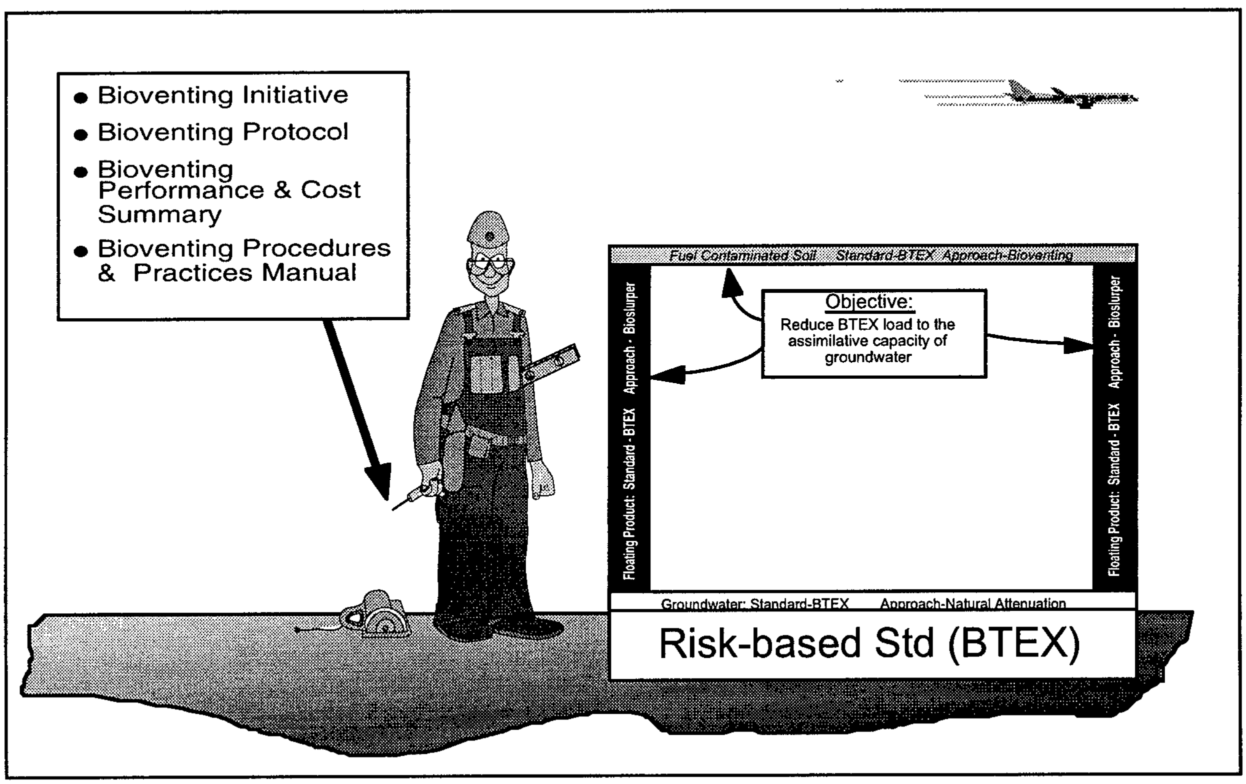

Figure 6

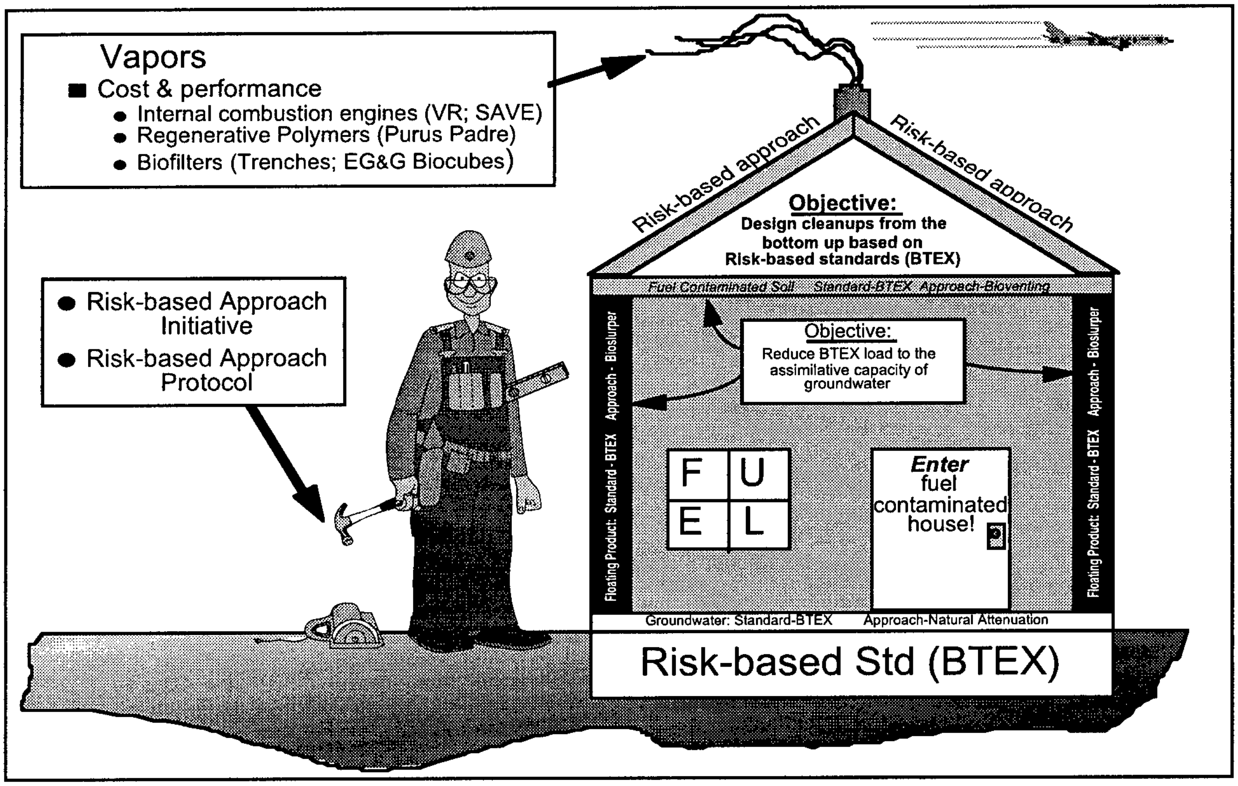

Figure 7

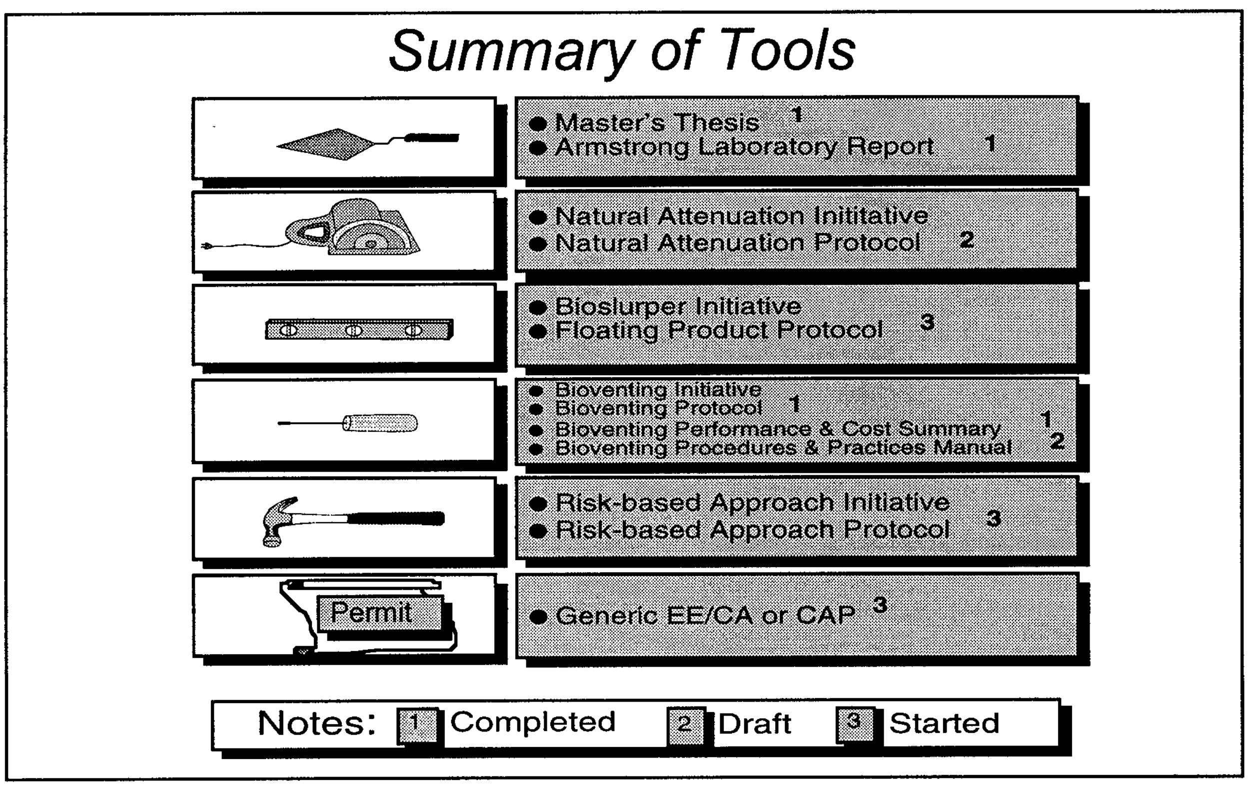

Figure 8