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Stakeholder Acceptance Analysis: ResonantSonic Drilling

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Prepared for the U.S. Department of Energy's
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STAKEHOLDER ACCEPTANCE ANALYSIS

RESONANTSONIC DRILLING

Prepared by

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for
U.S. Department of Energy
Office of Technology Development

December 1995

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INTRODUCTION

This report presents evaluations, recommendations, and requirements concerning ResonantSonic Drilling (Sonic Drilling), derived from a three-year program of stakeholder involvement. Sonic Drilling is an innovative method to reach contamination in soil and groundwater. The resonant sonic drill rig uses counter-rotating weights to generate energy, which causes the drill pipe to vibrate elastically along its entire length. In the resonant condition, forces of up to 200,000 pounds are transmitted to the drill bit face to create a cutting action. The resonant energy causes subsurface materials to move back into the adjacent formation, permitting the drill pipe to advance. This report is for technology developers and those responsible for making decisions about the use of technology to remediate contamination by volatile organic compounds. Stakeholders' perspectives help those responsible for technology deployment to make good decisions concerning the acceptability and applicability of sonic drilling to the remediation problems they face.

The report provides:

- Stakeholders' final evaluation of the acceptability of Sonic Drilling in light of the technology's field test.
- Stakeholders' principal comments concerning Sonic Drilling.
- Requirements that stakeholders have of any remediation technology. Technology decision makers should take these conclusions into account in evaluating the effectiveness and acceptability of any remedial method proposed for their site.

In addition, the report presents Hanford stakeholders' data requirements for the technology's field demonstration as well as detailed comments on Sonic Drilling from stakeholders from four other sites throughout the western United States.

STAKEHOLDER INVOLVEMENT PROCESS

The Volatile Organic Compounds in Arid Soils Integrated Demonstration (VOC-Arid ID) extensively involved stakeholders in the evaluation of innovative technologies to remediate contamination by VOCs. The stakeholder involvement program identified data requirements and issues at five arid sites. Data requirements are needs for specific information about a technology and its performance. They derive from questions about a technology's demonstration and operation. Issues and concerns are requirements and conditions for the acceptability of a technology; an example is "Technologies should be versatile in application and not transfer contaminants from one environmental medium to another."

A goal of the VOC-Arid ID was to test a technology once and then be able to deploy it broadly by ensuring that test plans for technologies to be demonstrated at one site included the issues, concerns, and data requirements of stakeholders from other sites where the technology was likely to be used. Ultimately, the process was designed to expedite deployment of effective and acceptable remedial technologies by determining what stakeholders required of these technologies.

Stakeholder involvement proceeded in three phases. Throughout, innovative technologies were evaluated in comparison to technologies in current use ("baseline" technologies). In the first phase, through individual interviews, Hanford site stakeholders contributed to the development of criteria by which technologies would be evaluated. In focus groups, these stakeholders defined data requirements and posed questions to be addressed in technology demonstrations. An integrated workshop was then held to augment the demonstration plans for six technologies. The workshop included all of the Hanford stakeholders and the scientists and engineers developing and testing the technologies. The six technologies were:

- Passive Soil Vapor Extraction Using Borehole Flux
- Tunable Hybrid Plasma
- ResonantSonic Drilling
- In-Situ Bioremediation
- In-Well Vapor Stripping
- Membrane Separation

In the second phase of the technology evaluation program, 75 stakeholders from four other DOE arid sites accomplished two goals through individual interviews. First, they validated and further refined the data requirements, issues, and concerns identified by Hanford stakeholders. Second, they defined requirements specific to their site and region.

Demonstrations were subsequently completed for Passive Soil Vapor Extraction Using Borehole Flux, ResonantSonic Drilling, and Tunable Hybrid Plasma.

In the third phase of the technology evaluation program, principal investigators were interviewed to obtain answers to stakeholders' data requirements and questions in light of completion of technology demonstrations. These answers were recorded in the fourth column of a four column matrix (please see Appendix A). Demonstration results were provided to Hanford stakeholders, who used them to make final evaluations.

This report presents Hanford stakeholders' final evaluation of ResonantSonic Drilling.

STAKEHOLDER EVALUATION OF RESONANTSONIC DRILLING

This section contains four parts:

1. A summary of stakeholder evaluation of Sonic Drilling,
2. An overall evaluation of Sonic Drilling by Hanford stakeholders,
3. Interview comments that form the basis for Hanford stakeholders' final evaluation, and
4. A narrative of stakeholders' principal comments about Sonic Drilling.

Summary of Stakeholder Evaluation of Sonic Drilling:

Most stakeholders favorably evaluated a number of Sonic Drilling's attributes, finding it, in many respects, an acceptable technology. However, they pointed out the necessity of finding the technology's most technically and environmentally sound application. And several of the technology's aspects continue to raise pointed concern.

Sonic Drilling's basis of support lies in its speed and economy, and in the fact that the technology requires no drilling fluids, and thus generates little process waste. Many stakeholders point to what they consider to be inordinately high drilling costs at Hanford. They regard Sonic Drilling as offering significant savings, particularly in comparison to cable tool drilling. The technology's drilling rate also influenced stakeholders' favorable evaluation.

Conversely, significant questions remain in the minds of some stakeholders about Sonic Drilling's effect on the sidewalls of boreholes. Some stakeholders, particularly state regulators and representatives of Native American tribes, raise concern that the sonic drill pipe, when in a resonant condition, compacts subsurface materials in the borehole sidewall, restricting the movement of soil vapor and groundwater. Other stakeholders, pointing to the considerable energy concentrated at the sonic drill bit, raise concern about the technology's generation of heat and energy and its ability to provide adequate core samples.

Stakeholders, while in many ways finding Sonic Drilling acceptable, say that it is important to be realistic about the technology's limitations, and to find the most productive application for the technology.

Overall Evaluation of ResonantSonic Drilling

The regulators participating in the final evaluation found Sonic Drilling acceptable for specified applications. Several remained concerned about the use of the technology for drilling below the water table, the issue of sidewall compaction, and the technology's cost.

All the public interest group representatives found the technology acceptable as did the technologists, with one concerned about the technology's ability to provide good quality core samples during drilling, and another remaining concerned about the energy and heat sonic drilling puts into the subsurface.

One tribal representative judged the technology acceptable if costs can be kept down. Another found Sonic Drilling unacceptable for reasons of sidewall compaction and inability to produce good quality core samples. The table on the following page lists specific assessments.

Overall Evaluation of Acceptability

Comment	Stakeholder Categories
OVERALL EVALUATIONS	
• View it as a means to an end -- a versatile tool, not a remediator.	• Regulator
• Very valuable for certain purposes.	• Regulator
• Only good for limited application. Do not use below the water table.	• Regulator
• Good technology that has a role to play, but is priced too high.	• Regulator • Tribal Rep
• It is important to find the most appropriate use for sonic.	• Regulator
• Technology is useful overall.	• Public Interest Group Rep
• No barriers remain to full deployability.	• Public Interest Group Rep
• Recommend maintaining a cable tool "core competency." Use sonic in conjunction with cable tool.	• Public Interest Group Rep
• It makes sense for sites requiring deep drilling.	• Technologist
• Acceptable, with one concern about core samples/characterization during drilling.	• Technologist
• No reservations.	• Technologist
• Unacceptable. Not good for drilling below the water line. Sonic would be a disaster in hard rock.	• Tribal Rep

Final Evaluation Interview Comments

In focus groups during the initial phase of the stakeholder involvement program, Hanford stakeholders identified data requirements and questions to be addressed in technology field demonstrations. The demonstrations provided answers to these data requirements and questions. Results were recorded in a four-column matrix (please see Appendix A) and subsequently provided to stakeholders. Hanford stakeholders used these results to develop a final evaluation of the technology. The following table records interview comments concerning ResonantSonic Drilling.

Comment	Stakeholder Categories
BENEFITS AND DRAWBACKS	
• We need new technology for drilling. Sonic's angle drilling capability is a benefit.	• Regulator
• Sonic Drilling may be good for coring, getting samples, and evaluating the location of DNAPLs, but may be less good for purposes of extraction. The recent difficulties with lack of production in two Sonic-drilled wells at Hanford may be the result of screen size and slot arrangement, not the action of the Sonic drill. It is important to find the most appropriate application for Sonic Drilling. Sonic Drilling and cone penetrometer make an effective combination. Both are great tools for geophysical logging.	• Regulator
• Pluses are cost, speed, angle drilling capability, and the fact that down time has been reduced. Useful with cone penetrometer for downhole characterization. May become the standard tool. Its capabilities will allow letting better contracts. The cost curve is moving in the right direction. Drawback is bad press from two non-performing production wells.	• Regulator • Technologist
• Speed, safety, lack of surface contaminants, and lower cost are all benefits. Sonic's drilling rate is excellent. There is no generation of waste, water, or dust on the surface. But the lower costs have not been borne out. The two failed wells had tremendous cost overruns.	• Regulator
• Benefit is potential to advance holes rapidly through difficult geology. Sonic is effective in Hanford's subsurface conditions. Drawback is that cost continues to seem quite high. Sonic is a good technology that technology developers are asking more for in terms of operating cost than necessary. Sonic has a role to play but is priced too high.	• Regulator

BENEFITS AND DRAWBACKS (Continued)	
• Advantages are speed, efficiency. Angle drilling ability is particularly useful for characterization and remediation specifically around tanks. Drawback is that reliability has not been assured.	• Regulator • Public Interest Group Rep • Technologist
• Huge benefit of Sonic Drilling is that you avoid the problem of RCRA waste handling with less contamination brought to the surface. Speed and lower cost are also benefits. $253 a foot is attractive when compared to drilling costs in the past. Angle drilling is an advantage.	• Regulator
• Benefits are less waste, less drill cuttings, angled drilling, versatility, acceptable cost. Drawbacks are breakdown rate and high maintenance needs.	• Public Interest Group Rep
• Length of training time for operators is a significant issue. A drawback is that sonic is not the best drilling method for characterization because of disaggregation of core samples in some circumstances. Benefits are speed, cost, and angle drilling capability.	• Public Interest Group Rep
• Appears to be less intrusive than current methods. The technology is effective and reasonable.	• Public Interest Group Rep
• Drawbacks include that this is a less than mature technology, unconsolidation of core samples in sandy soil, the up-front cost of the drill system, and increased training time for operators.	• Technologist
• Sonic is not good for drilling below the water line. Vibration causes fine soil material to pack in next to the drill rod and restrict permeability. Restricting of porosity may affect characterization. Drill pipe has to be pulled periodically, slowing the technology's drilling rate. Sonic makes a poor quality borehole by causing formation damage. Sonic produces poor quality core samples. Cores are disturbed, sometimes pulverized by the energy in the Sonic drill head. The Sonic vibration causes core growth. Sonic Drilling would be a disaster in hard rock.	• Tribal Rep
PERFORMANCE • Can it drill deep enough?	 • Regulator
• The marketing effort has oversold Sonic, alienating some technical people. Need to select best uses. Sand pack and too small screens may have been the problem with the non-producing wells drilled by Sonic. Need to show that the problem has been solved that led to sidewall compaction in production wells. Not willing to close the door on Sonic yet. It would be bad if the next series of wells drilled by Sonic has problems. The Hanford ER program can't afford to put in two more non-producing wells.	• Regulator

Comment	Stakeholder Categories
PERFORMANCE (Continued)	
• How severe are changes to soil as result of resonance? Concern about sidewall compaction restricting in-flow. In an area where wells are producing 70 gallons per minute of water, wells drilled by Sonic produced only 6 - 7 gallons per minute. The problem is that Sonic seems to be sealing the formation, reducing hydraulic conductivity. Drillers are overcompensating by enlarging screen size and through in-well design. Ecology would like to analyze side wall compaction.	• Regulator
• Determine how accurate and precise you can be with Sonic Drilling. How flexible is it? The noise issue can be dealt with. Provide clearer comparisons with other drilling techniques.	• Regulator
• Concerned about the effect Sonic's noise will have on nearby wildlife when technology is operated for long periods, particularly in shrub steppe with rare and endangered species. Demonstration results show a good improvement in down time	• Regulator
• Provide noise ratings for the technology in commonly understood terms. Provide results of tests concerning subsurface seismic disturbance.	• Public Interest Group Rep
• Does sleeve remain after the drilling is complete? Information not reported on possible seismic disturbance. Does the drill bit need to be changed for combo-rig? What was done to reduce downtime? Question replicability in other types of geology. Use of liquid to cool drill head appears to contradict claim that it doesn't have drilling liquid as by-product. Provide a total energetics analysis. Concern that the technology is not capable of drilling the diameters required to accommodate extraction equipment.	• Public Interest Group Rep
• The temperature of the Sonic drill bit needs to be monitored.	• Public Interest Group Rep
• Heat of drill head is concern, but satisfied that the liquid is a sufficient coolant. Sonic is as good as cable tool.	• Technologist

Comment	Stakeholder Categories
PERFORMANCE (Continued) • Concerned about core recovery and increased soil temperature. Undisturbed samples are important. How can chilling of sampling equipment resolve problem with heat generated by resonance? Do not believe that chilling the drill head solves the problem of increased temperature because of the tremendous energy going into the soil. Concerned about the heat and energy Sonic puts into the soil and the effect of this heat and energy on soil samples. Technology proponents must adequately address sonic's temperature effect on soil. Need evidence that Sonic's energy is not transferred further down into the soil. Sonic is great in combination with cone penetrometer. It is important to be realistic about the technology's limitations.	• Technologist
• Concern about the integrity of the soil samples achievable with Sonic.	• Technologist
• Concern over need for liquid to cool drill-head. Does it get contaminated? Clarify if Sonic is able to core through solid rock. Compare the cost of drilling through soils and hard rock.	• Tribal Rep
• In terms of the claim that Sonic creates less drilling waste, the "waste" is going into the formation, is forced, is over-compacted into the sidewall. The baseline should be air rotary. It's the standard in the drilling industry.	• Tribal Rep
COST • It's unrealistic to make cost estimates in comparison to cable tool. In the oil and gas industry, cable tool was gone by the mid '50s. Air rotary may be cheaper than Sonic.	• Tribal Rep
• Profit motive by Bechtel, Westinghouse, and PNL is preventing the use of low cost technologies. The Hanford site needs incentives to use cheaper technologies; needs an incentive to get sonic applied. Well drilling is too expensive at Hanford. At 200 ZP1 it cost more than $ .3 million to drill three wells. No cost savings over ODEX/air rotary.	• Regulator
• Need greater cost analysis. Sell drill as commodity with customer being the drilling community.	• Regulator
• Sonic is a great asset to the cleanup effort because one of the highest costs at Hanford is drilling.	• Public Interest Group Rep
• Provide break out of costs and cost scenarios for drilling in rock and in soil. Identify the reasons for high drilling costs. Why does drilling on the Hanford Reservation cost so much more than off? Costs are the whole issue. Sonic's cost of $253 a foot is a tremendous cost - need to justify it.	• Tribal Rep

Comment	Stakeholder Categories
APPLICATION	
• Sonic and cone penetrometer make an effective combination for characterization. Both great tools for geophysical logging. Sonic has potential to be used in rad zones for the evaluation/ characterization of cribs and trenches. Possibly use Sonic with a crane. It is important to find the most appropriate application for Sonic.	• Regulator
• Very pleased with results for work with cone penetrometer for down hole characterization. Now have good delineation of contaminant zone and better estimates of contaminants. For well drilling, agree with Ecology that some damage at production well was due to Sonic; however, believe it is good choice above the water table. Use sonic down to the water table and then go with cable tool or air rotary. May become the standard tool. Its capabilities will allow letting better contracts.	• Regulator
• Technology should not be used for VOC recovery, core sampling or precision needs. Recommend a moratorium on using Sonic below the water table. Need to think carefully about nature of soil and type of well. Important to choose the right application.	• Regulator
• Fine for Hanford. Many other markets could be available including water supply drilling, agriculture, oil and gas drilling.	• Regulator
• Best use of Sonic is in vadose monitoring and remediation. ("Cable tool is a very painful way to drill.")	• Regulator
• Sonic may be better used where you don't need good core samples. Sonic can drill through boulders and should be more effective in clay than cable tool. The resonance should reduce the friction coefficient. Could be used at the tanks farms to install frozen subsurface barriers.	• Regulator
• Combination with cone penetrometer fantastic, capturing the soil in the 6-foot tubes is valuable to see soil complexity. Great for "blasting" holes, not precision needs. Accept limitation put on the technology due to using energy to break soil. Good for depth, not shallow. Makes sense for sites requiring deep drilling. Important to be realistic about Sonic's limitations.	• Technologist
• The shifting, unconsolidation of soils is a barrier to use for characterization. Use Sonic in conjunction with one or two compatible drilling technologies.	• Technologist
• Concern that the technology is capable of drilling the diameters required to accommodate extraction equipment.	• Public Interest Group Rep

Comment	Stakeholder Categories
USE AT HANFORD	
• Cribs and trenches	• Regulator
• Can it go the 500 feet at Hanford?	• Regulator
• In-situ characterization	• Regulator
• Wouldn't hesitate to use it. Sonic is effective in Hanford's subsurface conditions.	• Regulator
• Want Sonic to go ahead but recent results are discouraging. Two non-producing wells were a major setback.	• Regulator
• No show stoppers, but reduce down time. Acceptable for use at Hanford.	• Regulator
• Drilling costs at Hanford are out of this world due primarily to permitting requirements. Why does it cost 10 times as much to drill a well on the Hanford site as it does just down the road off-site.? Cost is paramount.	• Technologist
• Sonic makes sense for the Hanford site, and is acceptable for certain purposes. Costs at Hanford make tool cost effective, but may not be elsewhere. It is not acceptable to spend $.25 million to put in one well at Hanford.	• Technologist
• Sonic is cheaper than baseline, but what's going to happen to its cost when it's moved into the Hanford system? Hope that Sonic will fit well with the management and integration system for managing Hanford. The question needs to be asked: Do we need new wells at Hanford, and by extension what will be the need for a drilling method such as Sonic.	• Public Interest Group Rep
• Sonic is not good for drilling below the water table. Sonic makes poor quality boreholes, and produces poor quality core samples. The baseline should be air rotary.	• Tribal Rep
OTHER ISSUES AND COMMENTS	
• Clarify the writing about the technology.	• Technologist • Public Interest Group Rep
• Do simpler comparisons, including noise and efficiency.	• Public Interest Group Rep

Stakeholder Principal Comments Concerning Sonic Drilling

Process waste. Stakeholders, pointing to the potential for drilling fluid to move contamination, find Sonic Drilling's ability to operate without drilling fluid an advantage.

Time. In most stakeholders' evaluation, Sonic Drilling's speed recommends its use.

Cost. Stakeholders see Sonic Drilling as offering savings; many see drilling costs as one of the greatest expenses at Hanford, and inordinately high. On the subject of cost, one stakeholder said, "Sonic is a good technology that technology developers are asking more for in terms of operating cost than necessary. Sonic has a role to play but is priced too high." Another stakeholder observed that although Sonic Drilling costs averaged $253 per foot as compared to $441 per foot for cable tool drilling, $253 was still too high.

Practicality/Works as Intended. With several pointed exceptions, many Hanford stakeholders see Sonic Drilling as useful overall, and effective in Hanford's subsurface conditions.

Stakeholders had a range of views concerning the most appropriate application for Sonic Drilling. Some said that Sonic Drilling may be good for coring, getting subsurface soil samples (geophysical logging), and for evaluating the location of dense non-aqueous phase liquids (DNAPLs), but may be less good for extraction. Others feel that Sonic is not the best drilling method for characterization because of what they see as the technology's potential to disaggregate, even pulverize, core sample, and to add heat to them, possibly leading to mischaracterization of volatile organic compounds.

A question remains in at least one stakeholder's mind about the effect on subsurface soils of the considerable heat and energy Sonic Drilling generates.

One reason stakeholders favored Sonic Drilling's deployment was its ability to drill on an angle. Stakeholders saw this capability as uniquely advantageous in terms of remediation of high-level waste tanks.

In mid 1995 Sonic Drilling installed two wells on the Hanford site that produced water at only a fraction of the rate of nearby wells drilled with cable tool. This lack of production raised some stakeholders' concerns about Sonic's potential to compact the sidewalls of boreholes. Some stakeholders took this situation as evidence that Sonic should not be used to drill wells below the water table. Others said that the lack of production may be the result of screen size and slot arrangement, not the action of the Sonic drill. For stakeholders, this situation clearly points to the need to determine Sonic Drilling's best application.

Environmental Impact. In order to be acceptable, the noise of Sonic Drilling's operation must not harm wildlife, particularly rare or endangered species found on the Hanford site. Noise ratings must be provided in commonly understood terms. Technology developers, some stakeholders feel, have yet to adequately address the question of the effect of Sonic Drilling's subsurface vibration on nearby structures, geology, and cultural resources.

Worker Training. Stakeholders see Sonic Drilling as a sophisticated technology requiring thorough training of operators.

Comments Concerning Sonic Drilling from 75 Stakeholders at Four Arid Sites Other Than Hanford

These assessments were recorded before the technology's field test.

ISSUES BY CATEGORY	SITES WHERE ISSUES RAISED	STAKEHOLDER CATEGORIES
Process Waste		
• The ability of Sonic Drilling to operate without drilling fluids, thus reducing secondary waste, is an advantage.	• INEL • Rocky Flats • Sandia	• Technologist • Regulator • Public Interest Group Rep Technologist
• Sonic Drilling brings less drilling media and subsurface material to the surface than other methods; this is an advantage.	• Rocky Flats	• Regulator
Practicality		
• Define the range of conditions in which this technology is effective, including the effectiveness of the technology in different geologic media, in heterogeneous soils, and at different depths.	• INEL • Los Alamos • Rocky Flats • Sandia	• Regulator Technologist • Public Interest Group Rep Technologist • Regulator Technologist • Regulator Public Interest Group Rep
• Assess the ability to drill on pattern, to handle large obstructions, to drill at different rates, to drill through a cased hole, to install instrumentation down-hole, to drill around corners, and to perform angled or directional drilling.	• INEL • Los Alamos • Sandia • Rocky Flats	• Regulator Technologist • Technologist • Regulator Technologist • Technologist
• Provide a more definitive evaluation of reliability, including the reliability of drill pipes, and methods for improvement. Assess the rate of equipment failure and provide quantitative results.	• INEL • Los Alamos • Sandia	• Public Interest Group Rep Technologist • Technologist • Public Interest Group Rep Regulator Technologist

ISSUES BY CATEGORY	SITES WHERE ISSUES RAISED	STAKEHOLDER CATEGORIES
Practicality (Continued)		
• Ensure that non-petroleum based drilling lubricants (e.g., vegetable oil) are used to avoid volatilizing petroleum-based lubricants and causing contamination.	• Rocky Flats	• Regulator
• Assess temperatures of a retrieved core at the point of retrieval, the temperature of the drill bit, depending on material of bit and soil types, and the potential effects of elevated temperatures on chemical and physical characterization accuracy.	• Los Alamos • Rocky Flats • Sandia	• Technologist • Technologist • Public Interest Group Rep Public Official • Technologist
• Compare Sonic Drilling to other drilling methods, including hollow-stem auger and air rotary drilling.	• INEL • Los Alamos • Rocky Flats	• Technologist • Technologist • Technologist
• Evaluate Sonic Drilling's ability to work in conjunction with the cone penetrometer and the SeaMist technologies.	• Sandia	• Technologist
• Explore the potential for explosion or catastrophic failure.	• Sandia	• Public Interest Group Rep
• Assess how uncased borehole walls hold up with Sonic Drilling in various soil types.	• Sandia	• Technologist
• Assess the effects of Sonic Drilling's vibration on nearby well's packing material used to seal the tops of screened intervals.	• Los Alamos	• Tribal Rep
• Evaluate other available sources for the technology; there appears to be a single vendor.	• Sandia	• Technologist
• Evaluate the effectiveness of Sonic Drilling in characterizing old landfills and drainfield areas by angle drilling.	• Sandia	• Regulator
• There is an advantage to Sonic Drilling in portability, in angled drilling without drilling fluid (no secondary waste), and for a wide range of applications	• INEL	• Public Interest Group Rep
• Consider using double-imploded steel used in Rocky Flats barrels for the drill pipe.	• INEL	• Public Interest Group Rep

ISSUES BY CATEGORY	SITES WHERE ISSUES RAISED	STAKEHOLDER CATEGORIES
Works as Intended		
• Evaluate the ability to achieve good-quality soil samples and representational cores.	• INEL • Los Alamos • Rocky Flats • Sandia	• Regulator • Tribal Rep Technologist • Public Interest Group Rep Technologist • Interest Group Regulator
• Evaluate the ability to drill 500' or more.	• Sandia	• Public Interest Group Rep
• Evaluate effects of water in the saturated zone that could potentially dampen vibration and slow drilling. Assess the ability to drill in an aquifer.	• Los Alamos • INEL	• Technologist • Regulator
• Define whether Sonic Drilling and the heat it generates alter the chemical or physical nature of the contaminants in samples or soil permeability.	• Rocky Flats • Sandia	• Public Interest Group Rep Regulator Public Official • Regulator Technologist
• The vibrating bit may vibrate soil particles into the formation, thus packing surrounding soil and skewing aquifer pump test results. Consider side-by-side comparison of wells drilled by different methods into the saturated and unsaturated zones to assess comparative effects on hydraulic conductivity.	• INEL • Sandia • Rocky Flats	• Regulator • Regulator • Technologist
• Define the benefits and limitations for well completion and usefulness for ground water monitoring, drill pipe clearances, and possible range of borehole diameters.	• Los Alamos • Rocky Flats	• Technologist • Technologist
• Demonstrate what happens when a sonic drill encounters a large subsurface boulder.	• Rocky Flats	• Regulator
• Assess efficiency when using drilling lubricants that contain no VOCs.	• Rocky Flats	• Regulator Technologist
• Confirm that no drilling fluids are needed.	• Sandia	• Regulator

ISSUES BY CATEGORY	SITES WHERE ISSUES RAISED	STAKEHOLDER CATEGORIES
Cost		
• Define the cost, speed, and effectiveness of this technology compared to other drilling technologies.	• Rocky Flats • Sandia	• Technologist • Public Interest Group Rep Regulator Technologist
• Evaluate the total cost, costs per unit depth, and cost effectiveness of this technology.	• Rocky Flats • Sandia	• Regulator Technologist • Regulator Technologist
• Assess costs of the technology considering its history in the oil and gas industry and in other DOE site demonstrations.	• Los Alamos	• Technologist
• Evaluate the cost of drill strings and drill pipes.	• INEL	• Public Interest Group Rep
• The lower cost of this technology is an advantage; the money saved can be applied to additional characterization.	• Sandia	• Public Interest Group Rep
Time		
• Compare VOC sample recoveries of Sonic versus air rotary and auger drilling, considering the time required to accomplish the job, the recovery rate, and personnel needs.	• Rocky Flats • Sandia	• Technologist • Regulator
Worker Safety		
• Consider automating the drilling operation to ensure that worker hearing damage does not occur and so that skilled labor is not needed.	• Sandia	• Public Interest Group Rep
• Mechanical resonance could pose a hazard to worker safety.	• Sandia	• Interest Group
• Evaluate potential for volatilizing VOCs from certain lubricants during drilling.	• Rocky Flats	• Public Interest Group Rep Regulator
• It is preferable not to drill through waste areas and drums, so angled drilling is an advantage, particularly at mixed waste landfills.	• INEL • Sandia	• Public Interest Group Rep • Public Interest Group Rep Technologist

ISSUES BY CATEGORY	SITES WHERE ISSUES RAISED	STAKEHOLDER CATEGORIES
Public Health and Safety		
• Evaluate the technology's potential to release air with contaminated dust (i.e., plutonium-contaminated soil).	• Rocky Flats	• Public Interest Group Rep
• Evaluate any feasibility of capturing the off gas or any airborne dust generated when drilling.	• INEL • Rocky Flats	• Public Interest Group Rep • Public Interest Group Rep
• Evaluate the negative impacts of vibration on structures in the area.	• Sandia	• Technologist
Environmental Impacts		
• Evaluate potential environmental impacts of the vibration, including soil permeability and contaminated dust release.	• INEL • Los Alamos • Rocky Flats • Sandia	• Tribal Rep • Tribal Rep Regulator • Public Official Public Interest Group Rep Regulator • Interest Group
• Evaluate the potential for drawing soil fines to the area of the well and affecting soil permeability.	• Los Alamos • Rocky Flats	• Tribal Rep • Public Interest Group Rep
• Directional drilling and subsurface networks are preferable to minimize surface impacts.	• Sandia	• Public Interest Group Rep
• Evaluate the noise impacts of the technology. Consider the ability to operate for limited hours per day to minimize nuisance.	• INEL • Los Alamos • Sandia	• Public Interest Group Rep Tribal Rep • Public Official Technologist • Public Interest Group Rep Regulator
• Assess the aesthetic impacts of the technology.	• Los Alamos	• Public Official
Public Perception		
• Define a monitoring system that will provide for public confidence.	• INEL	• Public Interest Group Rep

ISSUES BY CATEGORY	SITES WHERE ISSUES RAISED	STAKEHOLDER CATEGORIES
Tribal Rights and Future Land Uses		
• Assess the reaction of tribes to a noisy, vibrating "assault on Mother Earth".	• Los Alamos	• Public Official
• Address the need for well closure and the potential effects on future land uses and ground water uses.	• Sandia	• Public Interest Group Rep
Socioeconomic Interests		
• Assess the skills and training required of personnel to operate the technology.	• Los Alamos • Sandia	• Technologist • Public Interest Group Rep
Regulatory Infrastructure and Track Record		
• This technology is exotic and unproven. Present clear examples of where this technology is better than other technologies, including air rotary drilling, and why.	• Sandia	• Regulator
Regulatory Compliance		
• Assess the ability of the technology to comply with EPA NESHAPS regulations in terms of dust production and associated contaminants.	• Los Alamos	• Technologist
Other		
• The distinct advantage of Sonic Drilling is that it does not require drilling fluids and muds.	• Rocky Flats • Sandia	• Public Interest Group Rep Regulator • Technologist
• This is an attractive, promising technology.	• INEL • Rocky Flats • Sandia	• Technologist • Public Interest Group Rep Public Official Regulator • Technologist
• Remediation at the 903 Pad at Rocky Flats needs directional drilling.	• Rocky Flats	• Public Interest Group Rep
• Sonic drilling was approved for use at Rocky Flats OU 11.	• Rocky Flats	• Regulator

Appendices

Appendix A presents the four-column matrix developed by Hanford stakeholders and ResonantSonic Drilling's Principal Investigators. Appendix B presents the general comments of Hanford stakeholders concerning Sonic Drilling, recorded before the technology's field demonstration. Appendix C presents comments applicable to the development of any innovative technology. Appendix D offers a fact sheet describing the operation of the technology.

APPENDIX A

FOUR-COLUMN MATRIX

SONIC DRILLING			
FOCUS GROUP DATA REQUIREMENTS	**WORKSHOP COMMENTS**	**TEST PLAN ELEMENTS TO ADDRESS DATA REQUIREMENTS**	**DEMONSTRATION RESULTS**
1. Define the measurements to be taken in drilling characterization wells in order to address variations in anisotropy (the ratio of horizontal to vertical hydraulic conductivity).	1. Regulators regarded as very important the ability to do full-spectrum characterization during drilling. Stakeholders pointed out the value of gaining as much characterization data as possible, and identified the comparison to baseline characterization capabilities as the appropriate basis for evaluating sonic drilling's performance in this area. Rather than stressing the importance of particular characterization potential, such as the ability to address variations in anisotropy, participants noted the importance of providing a range of characterization potentials.	1. The test plan for fiscal year 1994 included core recovery elements as well as comparisons of chemical and physical analyses between sonic drilling and cable tool drilling. Two types of split barrel sampling were demonstrated: one for cable tool and one for resonant sonic. In both cases polycarbonate liner tubes were placed inside the barrels. In addition, sampling was attempted inside the resonant sonic core barrel as a field adjustment. Field tests involving analysis physical characteristics such as grain size analysis are scheduled for July - August 1995.	1. Core recovery was reported to be equivalent to that achievable with cable tool. However, three physical phenomena were observed for core samples obtained using the resonant sonic method. Those were: • "Core growth" or the apparent unconsolidation of consolidated strata so that a greater length of soil is extracted than was advanced through by the drill. This is believed to result from the sonic vibration on the sampled soil. • Grain size distribution appears to be different in sonic core samples than parallel cable tool samples when laboratory test are conducted on both. The mechanism and basis for this difference is being evaluated. • Loose sands and other unconsoli-dated soils were difficult and in some cases impossible to retain in the sampling device. In other words, they slipped out before retrieval. Results of chemical analysis compared favorably to samples taken from cable tool drilling. Acceptable core temperatures were achieved by chilling sampling equipment when VOC chemical sampling was planned.

SONIC DRILLING			
FOCUS GROUP DATA REQUIREMENTS	**WORKSHOP COMMENTS**	**TEST PLAN ELEMENTS TO ADDRESS DATA REQUIREMENTS**	**DEMONSTRATION RESULTS**
2. Define how the drilling process will accommodate contaminant characterization.	2. As noted above, all types of characterization data: chemical contaminant, radiological contaminant, soil profile, and moisture content, are considered desirable, especially by regulators, for drilling technologies.	2. See Requirement #1.	2. Some of the most successful sampling and drilling occurred with a newly deployed "combination rig" which has the capability to perform both resonant sonic drilling and cable tool drilling. This rig demonstrated flexibility and speed in the face of varying subsurface conditions.
3. Define the criteria and method for determining the quality of the core samples available from sonic drilling (e.g., size, composition, contaminants including co-contaminants).	3. Technology demonstrators noted that the purpose of drilling may not always include characterization and therefore characterization capability may not be a good measure of performance under some circumstances. A regulator remarked that additional characterization is almost always of value in subsurface work. The technology's PIs committed to a comparative evaluation of the characterization capabilities of sonic drilling.	3. The FY 94 test plan included the drilling and completion of two wells in the same stratigraphy, to the same depth (290 feet), of the same diameter (11 inches), ten feet apart. One was drilled using a sonic drill rig and the other using a cable tool rig. Sampling comparisons and general operational and cost performance comparisons were made. Field tests involving analysis physical characteristics such as grain size analysis are scheduled for July - August 1995.	3. Results from the side-by-side comparison of sampling capabilities show that chemical analytical results are quite comparable. However, the grain size distribution and degree of consolidation when examining physical parameters are different between the two methods. Sonic drilling seems to unconsolidate soil samples and seems to move grains between strata.
4. Define the range of borehole sizes and depths achievable with sonic drilling during demonstration. Compare results to baseline technical capabilities.	4. Technology demonstrators committed to defining the range of borehole diameters achievable with sonic drilling and to comparing these to what is achievable with cable tool.	4. The FY 94 test plan included drilling three 11-inch diameter holes to a depth of 310 feet. The test plan for FY 95 included plans for a 16-inch diameter hole to a depth of 250 feet. The 16-inch diameter resonant sonic demonstration has not occurred because the in-well vapor stripping demonstration, which was the planned use, was moved to Edwards AFB in California.	4. The 11-inch diameter holes to 310 feet deep were successfully completed. Cost and detailed performance comparisons show that there is a 42% cost savings and 62% time savings when sonic drilling is directly compared to cable tool drilling at Hanford.

SONIC DRILLING			
FOCUS GROUP DATA REQUIREMENTS	**WORKSHOP COMMENTS**	**TEST PLAN ELEMENTS TO ADDRESS DATA REQUIREMENTS**	**DEMONSTRATION RESULTS**
5. List the soil types that are part of the sonic drilling demonstration. Assess the applicability of these data to other soil types.	5. Participants agreed that this is an important element of the demonstration. PIs agreed to provide information for all soil types encountered. They regarded extrapolation to other soil types as difficult. Technology demonstrators noted that empirical data about the technology's performance in different soil types was probably more accurate. Stakeholders noted that lack of extrapolations would make determinations by potential users more difficult and thereby limit deployability. PIs agreed to attempt to make soil type performance extrapolations.	5. The test plan has included drilling in medium to coarse gravel, mixed gravel, clays, and boulders (rocks greater than one foot in diameter). Information is needed on sonic drilling's performance in fine-grained sands. Performance results are being compared to cable tool drilling in similar soil types.	5. Unconsolidated sands require the use of minimal fluid to maintain borehole integrity and reduce soil temperature increases. Coring through boulders requires the addition of fluid to cool the drill bit. Both of these issues continue to be addressed for improvement. The performance in fine, medium and course gravel and clay soils has been very good and very fast. The combination rig (multiple drilling options) mentioned in item #2 above, has demonstrated success in variable soil conditions.
6. Define how the demonstration will measure temperatures at the drill bit during sonic drilling. Define the effects of those temperatures on VOC measurement in the soil. Measure how these effects vary with the size and depth of the boreholes.	6. PIs said that the demonstration would monitor temperatures at the drill bit, compare VOC samples obtained using sonic drilling to those obtained using cable tool drilling, and use a split spoon sampler ahead of the drill head to obtain samples unaffected by temperature.	6. The test plan did not include down-hole monitoring of drill bit temperatures, but rather included measurement of the temperature of core samples as they were removed from the hole. The soil in the center of the extracted core was measured before it was removed from the drill pipe or other sampling device, thus representing the temperature at the advancing drill bit as closely as possible. Principal investigators (PIs) estimate that samples dissipate no more than five degrees of temperature on being drawn out of the hole.	6. VOC recovery has proven to be equivalent to cable tool in field testing. See Item #1 for additional results.

SONIC DRILLING			
FOCUS GROUP DATA REQUIREMENTS	**WORKSHOP COMMENTS**	**TEST PLAN ELEMENTS TO ADDRESS DATA REQUIREMENTS**	**DEMONSTRATION RESULTS**
7. Define the differences in skill level and training required to operate a sonic drill versus a cable tool rig (years experience, level of training and refresher training, types of technical knowledge, and number of personnel needed).	7. After extensive discussion on how to define and measure this parameter, it was agreed that minimum skill requirements for sonic drill operators would be documented and reported in the technical evaluation. It was agreed that this parameter is not something to be tested, but rather compared in an evaluation report. (Participants agreed that the skill required to operate a sonic drill rig is higher than that required to operate a cable tool rig.)	7. The report on demonstration results notes that operators undergo a two-year apprenticeship before being qualified to operate the sonic drill. This is a substantial apprenticeship and includes many technical and operational elements. Operators need to have a strong mechanical aptitude and the ability to visualize the action of the drill head in the subsurface.	7. Specialized drilling workers are required and training has been successful. There have been operators available to date.
8. Define worker safety performance achieved during the demonstration and compare these to baseline technology records (e.g., days lost, injury accidents, exposure records).	8. Stakeholders saw this issue as directly related to the above-noted skill level and training requirements. Again, no specific test plan element was seen as necessary, but inclusion in the technology evaluation report was deemed appropriate. Technology developers agreed that data on the issue would be included in the report.	8. The test plan has provided for records to be kept of industrial health and safety performance.	8. As of April 1995, there have been no injuries associated with sonic drilling in three years of testing at the Hanford Site.
9. Determine noise levels associated with sonic drill operation. Compare these levels to those of the baseline technology.	9. PIs said that noise levels are being measured during the test and the data will be reported and compared to levels experienced when using cable tool.	9. The test plan measured decibel levels within 50 feet of the sonic drill rig and beyond the 50-foot "exclusion zone." Both measurements were compared to measured decibel levels associated with a cable tool drill rig.	9. Sonic drilling noise levels within the 50-foot exclusion zone were between 85 and 95 decibels. Sonic drilling noise levels outside the 50-foot zone were 85 decibels or lower. The noise levels associated with cable tool drilling while driving casing were 85 to 110 decibels within a 100-foot radius. All activity in exclusion zone is done wearing hearing protection.
10. Define the criteria that will be used to measured functional reliability (e.g., hours per day functioning without breakdown, availability of replacement parts, maintenance costs and schedule, feet per hour drilled during operation).	10. Stakeholders saw this issue as being directly related to items 5 and 11. The interrelationship of speed, effectiveness, cost, and general efficiency were all factors that stakeholders want to see compared directly to the baseline technology. Participants suggested a matrix that would show the various aspects of performance and the conditions under which performance was measured. In this way all the elements of a new technology's performance could be evaluated in an integrated manner.	10. The test plan measured rig-caused downtime in relation to attempted run time. Externally caused downtime, such as delays due to regulatory actions, were not included in this calculation.	10. On the basis noted, the resonant sonic drill rigs have experienced less than 10% downtime during the latest testing. This has been reduced from greater than 50% during 1991 and 1992.

SONIC DRILLING			
FOCUS GROUP DATA REQUIREMENTS	**WORKSHOP COMMENTS**	**TEST PLAN ELEMENTS TO ADDRESS DATA REQUIREMENTS**	**DEMONSTRATION RESULTS**
11. Define costs of obtaining and operating sonic drilling: capital costs, operating costs, maintenance costs, and other costs.	11. Participants noted that maintenance costs, repair costs, downtime costs, and training costs must be included in the technical evaluation document. DOE's cost for the demonstration may not be fully representative of actual cost of operation.	11. The test plan includes provisions to compare costs from three pairs of two-well sets. Each well set includes one well installed with sonic drilling and one installed with cable tool. The well sets have been completed in close proximity, are in similar geologic formations, and were put in during roughly the same time period.	11. At Hanford, resonant sonic drilling costs averaged $253 per foot compared to an average of $441 per foot for cable tool. In addition, comparable resonant sonic wells were completed in an average of 12 days versus 32 days (on average) using cable tool method.
12. Measure vibration effects of sonic drilling on nearby structures and activities. Define how the results may be applicable to other locations.	12. Stakeholders asked if the sonic drill had potential to destabilize subsurface faults or other seismic features and thus cause surface disturbances. Technology developers said that measurements would be made. They believe the technology will not cause subsurface seismic disturbances.	12. The test plan for FY 95 included measuring the vibration effects away from a sonic-drilled hole. Three 60-foot deep measurement holes were installed in a straight line, ten feet apart. Each of these holes had six triaxial accelerometers installed at 10-foot intervals down the hole. A sonic drill rig was positioned 60 feet away from the middle measurement hole, perpendicular to the 3-well line. The sonic drill rig drilled a 60-foot deep hole. This process was repeated three times, at 40 feet, 20 feet, and 5 feet from the center measurement hole, to determine vibration effects, if any.	12. Analysis of the data obtained from the noted tests are being evaluated using a subsurface structural computer program so that any effects on various types of structures can be predicted. These results are pending.
13. Define how volatilized VOCs emerging at the ground surface will be captured and controlled during drilling.	13. Technology demonstrators noted that, in this technical area, there is no difference between sonic drilling and cable tool. Stakeholders noted that VOCs might be volatilized by elevated temperatures at the drill head (See item 6). ID technical staff noted that surface VOC emissions would be monitored and measured and the results compared to those of baseline technology.	13. The test plan calls for the drill pipe to be capped during normal drilling. When the cap is removed, a system called the "Guzzler Air Filtration System" is used to capture off-gases.	13. The demonstration used the noted Guzzler system in series with a HEPA filtration system. The HEPA filter system is 99.99% effective for filtering particles greater than one micron in size. The air handling system may have GAC added as a polishing step if required.

SONIC DRILLING			
FOCUS GROUP DATA REQUIREMENTS	**WORKSHOP COMMENTS**	**TEST PLAN ELEMENTS TO ADDRESS DATA REQUIREMENTS**	**DEMONSTRATION RESULTS**
14. Define demonstration criteria and a method for evaluating the level of corrosion failure and pipe failure for sonic drilling (e.g., what constitutes failure, number of failures per 100' of completed hole).	14. Technology demonstrators said that pipe breakage was being measured during the demonstration. They will record conditions under which breakage occurs and patterns of malfunction. An evaluation of this element will be included in the performance report. (Stakeholders saw this performance element as being linked to item 12.)	14. A drill pipe design model was developed under the FY 94 test plan that is expected to result in an improved drill pipe design, therefore improving performance and drill pipe life. Field demonstration of these pipes verifying drill pipe design began in early 1995.	14. The new pipe and drill string is being demonstrated. There are still occasions of failure. In order to find other ways of addressing these failures, a computer drilling simulation model is being used to evaluate conditions under which the drill pipe fails or is likely to fail. It is believed that if drilling resonant frequencies can be appropriately metered and regulated for different soil types pipe failures can be further reduced.
15. Define test parameters to measure sonic drilling's ability to drill at an angle (e.g., drilling rate, achievable angles, linear distance limitations, borehole size limitations, quality of core samples retrieved).	15. Technology developers agreed that this testing will be part of the demonstration, and will provide data on performance.	15. Six 45-degree angle holes were drilled with the sonic drill rig in FY 94. These holes ranged in length from 110 to 170 feet. Some were continuously cored and sampled.	15. The speed of drilling for these angled holes was 2.5 times as fast as cable tool could install in a vertical mode. Moreover, cable tool cannot do angle drilling.
16. Determine power requirements for sonic drilling. Compare these requirements to requirements for the baseline technology.	16. Technology developers agreed to measure and incorporate this information into the performance report.	16. Power requirements for sonic drilling were determined in FY 94 testing.	16. Cable tool drilling typically requires 100 to 200 horse-power, while the sonic drill requires 150 to 1000 horse-power. It is important to note, however, that sonic drill rigs require approximately two thirds less time to complete the same length of hole.
17. Determine how the use of this technology will effect the rate of overall cleanup (e.g. speed up, slow down, or no effect).	17. Technology developers agreed to incorporate this information into the performance report to the degree it can be determined.	17. The speed of sonic drilling in comparison to cable tool drilling was compared in several ways and under various conditions during testing.	17. Sonic drilling is two to ten times as fast as cable tool drilling, depending on the soil type being drilled. Sonic drilling's average speed advantage at the Hanford site is three to four times that of cable tool. Because sonic drilling, in most formations, requires no drilling fluids, its use may accelerate the rate of overall cleanup and reduce secondary waste analysis and packaging costs.

APPENDIX B

HANFORD STAKEHOLDERS' COMMENTS CONCERNING SONIC PRIOR TO THE TECHNOLOGY'S FIELD TEST

DATA REQUIREMENTS - SONIC DRILLING	
1.	Define the measurements to be taken in drilling characterization wells in order to address variations in anisotropy (the ratio of horizontal to vertical hydraulic conductivity).
2.	Define how the drilling process will accommodate contaminant characterization.
3.	Define the criteria and method for determining core sample quality available from Sonic Drilling (e.g., size, composition, contaminants including co-contaminants available from Sonic Drilling).
4.	Define the range of borehole sizes and depths achieved with Sonic Drilling during demonstration. Compare results to baseline capabilities.
5.	List the soil types that are part of the Sonic Drilling demonstration. Assess the applicability of these data to other soil types.
6.	Define how the demonstration will measure temperature at the drill head during Sonic Drilling. Define the effects of those temperatures on VOC measurement in the soil. Measure how these effects vary with the size and depth of the boreholes.
7.	Define the differences in skill level and training required to operate a Sonic Drill versus a cable tool rig (years experience, level of training and refresher training, types of technical knowledge, and number of personnel needed).
8.	Define worker safety performance achieved during the demonstration and compare it to baseline technology records (e.g., days lost, injury accidents, exposure records).
9.	Determine noise levels associated with Sonic Drill operation. Compare these to levels for the baseline technology.
10.	Define the criteria that will be measured to determine functional reliability (e.g., hours per day functioning without breakdown, availability of replacement parts, maintenance costs and schedule, feet per hour drilled during operation).
11.	Define costs of obtaining and operating a Sonic Drill: capital costs, operating costs, maintenance costs, and other costs.
12.	Measure vibration effects of Sonic Drilling on nearby structures and activities. Define how the results may be applicable to other locations.
13.	Define how volatilized VOCs emerging at the ground surface will be captured and controlled during drilling.
14.	Define demonstration criteria and method for evaluating level of corrosion failure and pipe failure for Sonic Drilling (e.g., what constitutes failure, number of failures per 100' of completed hole).
15.	Define test parameters to measure Sonic Drilling's ability to drill at an angle (e.g., drilling rate, achievable angles, linear distance limitations, borehole size limitations, quality of core samples retrieved).
16.	Determine power requirements for Sonic Drilling. Compare these requirements to the baseline technology requirements.

APPENDIX C

STAKEHOLDER COMMENTS APPLICABLE TO ANY INNOVATIVE ENVIRONMENTAL TECHNOLOGY

An analysis of the stakeholders comments collected during the focus group meetings and individual interviews revealed concerns and data requirements that apply to all of the technologies evaluated. Those making decisions about the use of any environmental technology should take these perspectives into account. Comments are sorted into the following categories: performance, cost, environmental health and safety, regulatory issues, and socio-political issues.

PERFORMANCE

Potential to increase contaminant mobility. Stakeholders require that a technology not increase the mobility of contaminants it is designed to remediate.

Subsurface injection. Some technologies involve the injection of substances ranging from water to microorganisms. This injection raises stakeholders' concerns related to regulation (e.g. Washington State's non-degradation standard for groundwater), effects on groundwater levels, effects on indigenous microorganisms, or the ability to monitor and control the consequences of subsurface injection.

Transfer of contaminants from one environmental medium to another. Stakeholders oppose removing contamination from one area or environmental medium only to transfer it to another, for example from the subsurface to the atmosphere. Technologies that do not immobilize or destroy contaminants on-site will raise these concerns.

Ability to deal with co-contaminants. Stakeholders clearly express concern about a technology's ability to remediate all the contaminants it is likely to encounter. They are concerned about technologies that do not take care of the entire problem, leaving or mobilizing other contaminants. This is a particular concern with mixed radioactive and hazardous contaminants and important for in-situ technologies facing the challenge of residual co-contaminants.

Versatility. In a related issue, stakeholders prefer technologies that deal with a range of contaminants and that are effective in varying conditions of soil, temperature, climate, and other site conditions. Stakeholders will challenge the wisdom of investing in a technology with narrow application.

Process/Secondary waste. Although almost all remediation methods produce some type and quantity of process waste, there is significant stakeholder concern about how that waste will be treated, stored, transported, disposed of, or otherwise managed. Therefore, stakeholders will likely be critical of any innovative technology that generates secondary waste that concentrates toxicity or is more difficult to dispose of or recycle than secondary waste generated by a baseline technology.

Complexity. A technology's complexity of design and operation raises questions for stakeholders. There is a common belief that the more complex a technology, the more expensive it is, the more likely it is to fail, and the more costly and difficult it is to repair.

Maintenance and operation. Technologies that local labor can operate and maintain are preferable to those that require complicated, expensive off-site maintenance.

Auxiliary technologies. Stakeholders evaluate a technology within the context of the entire system within which it operates. In order to assess one component of the system, stakeholders point out that it is necessary to evaluate the benefits and drawbacks of the entire system. Technologies that require auxiliary components raise issues if the supporting technologies are not completely described, understood, or reliable.

Off-site treatment/transport. Off-site transport, treatment, or disposal of contaminants concern stakeholders. These considerations include the complexities of dealing with varying jurisdictional authorities, possible environmental and health exposure, and accidents, as well as the impact of treatment and disposal facilities.

Timeliness. A technology may have significant benefits in terms of effectiveness, cost or other attributes, but may operate more slowly than a baseline technology. In evaluating technologies, stakeholders take into account rate of performance and time required to complete the job. Many believe that time is of the essence in remediation, particularly in relation to blocking the migration of contaminated plumes.

COST

In evaluating technology, cost is important to stakeholders without taking precedence over certain other considerations, especially health and safety. Stakeholders are concerned about the following aspects of cost:

Cost greater than baseline. Stakeholders will be interested to know if the cost to develop, operate, or decommission a new technology is greater than for the baseline technology. A particular point of concern to stakeholders is life-cycle cost, including startup, operations, maintenance, and decommissioning. Stakeholders will ask to see a complete accounting of life-cycle costs.

Reduced budgets. Stakeholders point out that many decisions about technology development and deployment now have to be made in light of reduced budgets.

ENVIRONMENTAL HEALTH AND SAFETY

Stakeholders are interested in the effect any new technology may have on the health and safety of workers and the public. Specifically they will be concerned about the following:

Failure, and emissions or releases. This is a critical issue with stakeholders. Effects on the environment, the public, or on workers from the failure of a technology – which may range from release of contaminants to mechanical failure and injury – must be carefully considered. Stakeholders require that the ability to control and mitigate failure be built into any technology.

They are very concerned about any uncontrolled emissions or releases of contaminants or other hazardous materials resulting from installation, operation, or removal of a technology. Stakeholders require detailed information about the possible impact of releases on people, wildlife, vegetation, air, water, and soil.

Energy demand. The use of large amounts of energy, for example electric power, to construct, operate, remove, and decommission a technology will matter to stakeholders. A projected energy demand greater than for baseline will raise concern as will the possibility that using the technology and supplying it with energy will place an inordinate demand on or damage natural resources.

REGULATORY ISSUES

Track record/Regulatory precedence. A technology with no history of approval within the federal, state or local regulatory system will raise stakeholders' concerns. Regulatory precedence refers to the regulations and regulatory guidance needed to evaluate a technology's compliance. Regulators' familiarity with a technology reduces regulatory uncertainty. Stakeholders will also have concerns about a technology that requires many complex regulatory approvals.

SOCIO-POLITICAL ISSUES

Future options. Stakeholders evaluate unfavorably technologies they see as foreclosing future options for remediation or land use. They will likely prefer methods that promote unrestricted future use of currently contaminated sites, including spiritual, traditional, and practical uses. Stakeholders are critical of technologies that change the physical nature of the land itself, or that preclude future waste processing or other remediation.

Potential to impact natural or cultural resources. Any potential impact from a technology on resources valued by a particular community or region will raise significant concern among stakeholders. These resources include clear air and scenic vistas, drinking water/groundwater supplies, important habitats, open space, and tribal resources and traditional land uses.

Hanford stakeholders identified the following data requirements as applicable to all technologies.

DATA REQUIREMENTS - ALL TECHNOLOGIES
1. Demonstrate the technology considering differing geological conditions and with a broad range of contaminants and contaminant mixtures to measure its versatility.
2. Define the demonstration assumptions and expectations about the production, storage, treatment, and disposal of secondary waste from the technology.
3. Define the specific elements of risk and the risk management strategy to be used in the demonstration and in subsequent deployment of the technology.
4. Define the elements of and process for assessing operational readiness for the demonstration of the technology.
5. Define the liability implications and insurance requirements for the deployment of the technology.
6. Define the control mechanisms and methods of response to all potential technology failures.
7. Define the methods and equipment necessary to monitor the effectiveness of the technology both as an operating unit and with respect to effects on the environment.
8. Demonstrate that further cleanup action is not foreclosed by the technology's use.

APPENDIX D

FACT SHEET

Fact Sheet: Sonic Drilling
Category: Drilling

NEED:
Advanced drilling technologies are needed to reduce costs, minimize waste from drilling, and contain drill cuttings and effluents while drilling. Resonant sonic drilling is a promising method for several drilling applications including boring holes for characterization (to determine the location and extent of contamination); drilling groundwater monitoring, vapor, and water extraction wells; installing barrier holes; and obtaining continuous core samples from both vertical and inclined boreholes.

DESCRIPTION:
Resonant sonic drilling has three major components: a drill rig with a sonic head, a drill pipe, and a drill bit. The drill head uses counter-rotating weights to generate energy, which causes the drill pipe to vibrate elastically along its entire length. The drill head operates at frequencies close to the natural frequency of the steel drill pipe (up to 150 cycles per second). In the resonant condition, forces up to 200,000 lbs are efficiently transmitted to the drill bit face to create a very effective cutting action. The resonant energy causes sands, gravels, cobbles and even clays to relax into the adjacent formation just enough to permit the drill pipe to advance freely.

As the drill pipe moves through the ground during drilling, the walls of the steel pipe expand and contract helping to reduce any dampening of the vibrations caused by ground swelling. The drill bit can be designed to either push the soils into the borehole wall or modified to allow a continuous core to enter the drill pipe. Core samples can be continuously retrieved by using either a wireline latch or small inner rod retrieval assembly. A wireline latch is used to connect the core barrel (which runs inside the drill pipe) to the drill pipe. As the drill pipe is pushed into the ground, the core barrel fills with soil. Once the core barrel is full (at approximately 10 feet of drilling), the barrel is unlatched and removed from the drill pipe on a cable (wireline). The drill pipe is left in the ground at the depth to which the well was cored to support the borehole. After the core barrel is emptied at the surface, it is returned to the bottom of the borehole and relatched in the drill pipe. No drilling fluid is required with the sonic method, so the only byproduct from drilling is the core sample.

The output consists of high-quality core samples or data from downhole probes and sensors. Unused core samples are the only secondary byproduct from drilling because the resonant energy causes sands, gravels, cobbles and even clays to relax into the adjacent formation just enough to permit the drill pipe to advance freely.

ADVANTAGES:
The key advantages of the sonic drilling method are that the drilling rate is faster, it contains all drill cuttings, it minimizes secondary drilling waste and reduces the amount of liquid contained in those wastes, it improves sample quality in formations where the baseline method cannot retrieve high-quality samples (for example, caliche or boulders), and it increases safety because workers are exposed to fewer physical hazards and less contamination.

Additionally, sonic drilling decreases contamination of supplemental drilling components (which occurs with systems that require a circulation media), and maintains excellent contamination control at the collar of the borehole. It also drills at any angle, from horizontal to vertical.

CHALLENGES:

The major challenge is to improve the reliability of the drill pipe for resonant sonic drilling. A resonance monitoring system will be valuable in determining the threshold energy levels for the drill pipe design. In addition, an accurate measurement system to determine the thermal effects of the bit on the core sample is needed to develop bits which will maintain the integrity of the contaminants being characterized (for example, to avoid volatilizing organics), while achieving acceptable penetration rates. Directional drilling applications are also being evaluated.

Resonant Sonic Drilling