Attachment A

**Nuclear Waste Technical Review Board**
**Members and Consultants**

- Dr. John E. Cantlon, Chairman, is vice president emeritus of research and graduate studies and former dean of the graduate school at Michigan State University, East Lansing. His field of expertise is environmental science.

- Dr. Clarence R. Allen is professor emeritus of geology and geophysics at the California Institute of Technology, Pasadena, where he has served as director of the Seismological Laboratory and chairman of the Division of Geological Sciences.

- Mr. John W. Arendt of Oak Ridge, Tennessee, is senior consultant and founder of John W. Arendt Associates, Inc. and a specialist in safety, quality assurance, handling and processing of uranium.

- Dr. Garry D. Brewer is professor of resource policy and management and former dean of the School of Natural Resources and Environment at the University of Michigan, Ann Arbor.

- Dr. Jared L. Cohon, is the dean of the School of Forestry and Environmental Studies and professor of environmental systems analysis and mechanical engineering at Yale University.

- Dr. Edward J. Cording is professor of civil engineering at the University of Illinois at Urbana - Champaign and a specialist in rock engineering and underground engineering.

- Dr. Donald Langmuir is professor emeritus of geochemistry at the Colorado School of Mines in Golden and a specialist in ground-water geochemistry.

- Dr. John J. McKetta, Jr. is the Joe C. Walter Professor of Chemical Engineering emeritus at the University of Texas, Austin.

- Dr. Jeffrey J. Wong, is science advisor to the director of the Department of Toxic Substances Control of the California Environment Protection Agency, Sacramento, and a specialist in hazardous substance risk assessment and scientific team management.

The following two members whose terms expired in April 1994 have been retained as consultants until appointments to the vacant positions have been made by the White House.

- Dr. Patrick A. Domenico is the David B. Harris Professor of Geology at Texas A&M University, College Station, and a specialist in ground-water hydrology.

- Dr. Ellis D. Verink, Jr. is a Distinguished Service Professor of Metallurgical Engineering emeritus and former chair of the Department of Materials Science and Engineering of the University of Florida, Gainesville, and a specialist in corrosion.

**Interim Storage Report**
**U. S. Nuclear Waste Technical Review Board**
**Summary of Conclusions and Recommendations**

After reviewing about two-dozen technical and nontechnical issues, the Board believes that it is possible to find the right balance between disposal and storage. If the following approach is used, both short- long-term spent fuel storage needs can be addressed in a way that keeps the goal of repository development or permanent disposal on track.

First, the Board sees no compelling technical or safety reasons to move spent fuel to a centralized storage facility for the next few years. The methods now used to store spent fuel at reactor sites are safe and are likely to remain safe for decades to come. Despite some recent public opposition to utility efforts to develop additional storage, so far, utilities have been able to add new storage capacity at their sites when needed.

However, the Board believes that federal storage capacity will be needed in the future for two reasons. First, when a repository begins operating, a centralized storage capability will be needed to provide added flexibility to handle the waste. For example, storage would provide a buffer between the repository and the rest of the waste management system if waste emplacement rates in the repository are less than spent fuel acceptance rates. Storage capacity also offers technical advantages, such as allowing spent fuel to be mixed and matched to optimize the thermal loading of the repository to improve repository performance.

Second, commercial spent fuel storage needs will change markedly beginning around 2010. Until then, approximately 15,000 metric tons of new storage capacity will be needed at reactor sites. But beginning around 2010, large amounts of dry-cask storage will be required to allow removal of spent fuel from the storage pools of reactors that are being shut down. It is at this time that a federal storage facility operating at full scale will be most useful. A centralized facility will relieve utilities of the need to build new dry-storage capacity at shutdown reactors while accommodating any future institutional or technical uncertainties associated with the long-term storage of spent fuel.

Although currently prohibited by law, there is no *technical* reason why a centralized storage facility (and supporting transportation infrastructure) cannot be constructed prior to repository construction. In fact, because of the lead time needed for planning and development, the Board believes it would be practical to begin planning now for a federal storage facility(s) that can achieve full-scale operation (i.e., accept 3,000 metric tons/year) by 2010 when reactors begin shutting down in large numbers.

In the past whenever there has been a choice between storage and disposal, disposal has always been made the primary focus of the federal high-level waste management program. This is because the storage of commercial spent fuel is not an acceptable substitute for disposal. Ultimately, spent fuel (commercial and defense) as well as sizable amounts of high-level radioactive reprocessing waste will have to be disposed of. The Board believes that the nation needs both sustained progress toward a repository and a plan to address future spent fuel storage needs. However, efforts now to refocus the program from disposal to storage, especially at a time when budgets are tight, could jeopardize site-characterization and repository development efforts in three ways: (1) by competing with the disposal program for resources, (2) by causing a real or perceived prejudicing of a future decision about the suitability of the Yucca Mountain site, and (3) by eroding the impetus and political support for repository development.

Given the current stage of the Yucca Mountain site-characterization program and the fact that substantial new storage capacity will not be needed until 2010, the Board has concluded that it makes technical, management, and fiscal sense to await the decision on the suitability of the Yucca Mountain site for repository development before beginning development of a full-scale federal centralized storage facility. The Board believes that the following approach strikes the right balance between maintaining the national goal of permanent disposal while meeting future storage needs.

- *Disposal:* The nation has a program for developing a repository for the permanent disposal of spent fuel. So far, no technical reasons have been found for abandoning the site being characterized at Yucca Mountain. The Board believes that if the DOE can maintain the recent pace of underground exploration, testing, and analysis, sufficient information should be available to determine within five there is a high probability that the site, along with the appropriate engineered barriers, can provide long-term waste isolation. Therefore, the Board recommends that for the next several years the DOE continue to focus its primary efforts on evaluating the suitability of the Yucca Mountain site for repository development.

• *Storage:* The Board recommends that generic planning for a federal storage facility and for a supporting transportation infrastructure begin now at a funding level modest enough to avoid competition with the repository program. Development of a large centralized storage facility should be deferred until after a decision has been made about the suitability of the Yucca Mountain site for hosting a repository. Because of the increased advantages of having a storage facility located at an operating repository site, if Yucca Mountain proves suitable for repository development, the centralized storage facility should be located there. With adequate prior planning, activities could begin around 2000 to construct a storage facility that would be operating at full scale by 2010 — at the repository site. Operation by this date would largely eliminate the need to store significant amounts of spent fuel at reactors after they are shut down.

  The Board also recommends developing storage incrementally by limiting the amount that can be transported to Yucca Mountain until the repository has been licensed for construction. This will reduce the potential risks associated with linking storage to the earlier milestone of site suitability, rather than waiting until the NRC licenses the construction of the repository as required by existing law.

  The Board suggests planning now for a limited-capacity backup facility, similar to the one previously authorized by the Nuclear Waste Policy Act, for emergency storage to be located at an existing federal nuclear facility. The backup facility should begin only if a clear need for the facility is established. Its operation should be phased out once operation of a storage facility at the repository site commences.

The process of planning, licensing and developing a large federal centralized storage facility and the transportation infrastructure that goes with it will take time; estimates range from five to seven years. Even if passed into law now, none of the proposals before Congress would enable operation of a centralized storage facility to begin much before 2002 — and then not at full scale. With the spent fuel stockpile currently at 32,000 metric tons and growing at 2,000 metric tons per year, it will take as long as 30 years to empty the inventory at all the individual reactor sites. So, developing a centralized storage facility at Yucca Mountain now would only reduce, but not eliminate, the need to continue adding spent fuel storage capacity at reactor sites. The Board's suggested approach differs from currently proposed strategies only by the time it will take to determine site suitability — at most five years.

With respect to storage, 2010 is the key milestone. Being able to accept small amounts of spent fuel in 1998 or 2002 will address the storage concerns of only a few utilities. Being able to accept 3,000 metric tons per year for 30 years by 2010 will be necessary to avoid having substantial amounts of spent fuel sitting at shutdown reactors.

Given current funding projections, it appears that the Nuclear Waste Fund will be only marginally capable, at best, of supporting the long-term development and operation of a repository for the permanent disposal of spent fuel. Therefore, the costs of a limited federal storage facility could be recovered through a new fee assessed on the users of that facility. The costs of a large storage facility located at a repository site (which would be used for all spent fuel) could be recovered by increasing the current 1 mill-per-kwh fee going into the Nuclear Waste Fund. This would avoid having future taxpayers bear the costs of final closure of the repository.

These Board recommendations represent a departure from existing policies. The Nuclear Waste Policy Act currently links development of a storage facility to the construction of a repository. The Board recommends that development of a storage facility at Yucca Mountain be linked to the earlier decision about the suitability of the Yucca Mountain site as defined above.

This new approach is not free of risk. Given the inherent difficulties associated with proving safe repository performance over many thousands of years, a site-suitability decision would not be an iron-clad guarantee that the site could be developed as a repository. However, the Board believes that the risks of linking storage to a site-suitability decision, rather than to the NRC licensing decision, can be reduced if the DOE clearly delineates its site-characterization program and focuses on the timely completion of the needed scientific design and assessment activities *and* if it continues to work closely with the oversight groups (e.g., the NRC) that have been involved thus far with the program. Working closely with these groups can help ensure that the decision about the suitability of Yucca Mountain for repository development is technically sound.

Finally, successful development of a system for managing the nation's spent fuel and high-level waste will require sound program management and sufficient and consistent funding. Without adequate funding for *both* disposal *and* storage, a significant amount of spent fuel will remain in storage at reactor sites well after large numbers of reactors begin shutting down in 2010.

## Summary of Board recommendations

After evaluating various technical and policy-related considerations regarding federal centralized storage, the Board believes that it is possible to find the right balance between permanent disposal and temporary storage of commercial spent nuclear fuel.

1. Developing a permanent disposal capability should remain the primary national goal and, for the next several years, determining the suitability of the Yucca Mountain site should remain the primary objective of the DOE's waste management program. Assigning the Office of Civilian Radioactive Waste Management any significant new activities at this time could compete for funding and other resources with site-characterization and repository development efforts at the Yucca Mountain site.

2. The Board recommends that during the next several years *generic* planning for a centralized storage facility and for a supporting transportation infrastructure begin at a funding level modest enough to avoid competition with the repository program. From a technical, operational, and fiscal perspective, 2010 is the key milestone for storage. Therefore, plans should be made to have this storage facility operating at full capacity (able to accept 3,000 metric tons/year for 30 years) by about 2010. This will allow the federal government to remove the backlog of spent fuel from those plants already shut down and to empty the pools at other plants as shutdowns occur.

3. The *construction* of a federal centralized storage facility should be deferred until after a decision has been made about the suitability of the Yucca Mountain site for repository development. If Yucca Mountain proves suitable, the centralized storage facility should be located there.

4. The Board recommends developing storage *incrementally* by limiting the amount that can be transported to Yucca Mountain until repository construction has been authorized by the NRC. This will address the potential risks associated with linking storage to the earlier milestone of site suitability.

5. The Board also recommends reauthorizing limited-capacity backup storage, similar to the one previously authorized by the Nuclear Waste Policy Act, at an existing federal nuclear facility. *Actual development* of the backup facility should begin only if a clear need for the facility is established. Its operation should be phased out once the operation of a large centralized storage facility commences.

6. Because siting a centralized storage facility may be extremely difficult without a viable disposal program, if the site at Yucca Mountain proves unacceptable for repository development, the Board recommends that other potential sites for *both* disposal and centralized storage be considered.

# *Disposal and Storage of Spent Nuclear Fuel — Finding the Right Balance*

*A Report to Congress*
*and*
*the Secretary of Energy*

*Nuclear Waste Technical Review Board*
*March 1996*

# Executive Summary

The Nuclear Waste Policy Act of 1982, as amended, established a statutory basis for managing the nation's civilian (or commercially produced) spent nuclear fuel. The law established a process for siting, developing, licensing, and constructing an underground repository for the *permanent disposal* of that waste. Utilities were given the primary responsibility for storing spent fuel until it is accepted by the Department of Energy (DOE) for disposal at a repository — originally expected to begin operating in 1998. Since then, however, the repository operation schedule has been delayed several times, and according to testimony submitted to the U.S. Senate by the Secretary of Energy in December 1995, repository operations may be delayed again, perhaps until 2015. These delays, along with the absence of a federal centralized storage facility, similarly delay the prospect of federal acceptance and removal of the spent fuel from utility sites. As a result, much more commercial spent nuclear fuel will require *temporary storage* for much longer time periods than originally were anticipated.

Recently, as a result of concerns primarily on the part of nuclear utilities and public utility commissions, several legislative proposals have been introduced in Congress that would require the DOE to develop a federal centralized storage facility at or near Yucca Mountain, Nevada, that could begin accepting commercial spent nuclear fuel in 1998 or soon thereafter. In addition, a large group of state agencies and utilities have sued the DOE in the U.S. Court of Appeals for the District of Columbia to obtain a judgment that makes the DOE legally responsible to begin accepting utility spent fuel in 1998. These initiatives have placed storage at the forefront of the debate about the ultimate fate of spent fuel. They also portend a possible change in the nation's goal of timely disposal and a redirection in program focus — from permanent disposal to temporary storage.

*The Board is encouraged by recent progress…at Yucca Mountain, Nevada*

As a result of its technical review, the Board found the connection between storage and disposal to be key to any discussion about where to store commercial spent fuel. Although the DOE's disposal program has been subjected to much past criticism, the Board is encouraged by recent progress in site-characterization and repository development efforts at Yucca Mountain, the only site being characterized for potential repository development. The tunnel-boring machine excavated to the level of the proposed repository in November 1995. Key repository-level exploration and testing activities are being initiated. In addition, the DOE is making progress developing a clear and coherent waste isolation strategy, which should permit an improved delineation of priorities and a more efficient allocation of funds among the activities being conducted at Yucca Mountain. The Board believes that if the DOE can maintain the recent pace of underground exploration, testing, and analysis, sufficient information should be available to determine within five years if Yucca Mountain is suit-

able for repository development. Ironically, the changes being proposed in Congress to refocus program efforts on storage are coming at a time when previous investments in site characterization and repository development finally are beginning to pay off.

Debates during the past two decades about the storage of commercial spent fuel reflect the complexity of the issues, the diversity of perspectives, and the strongly held views of different stakeholders. Up to now, a broad consensus on this issue has eluded the nation. Ultimately, because of the controversy involved, any attempt to reach a decision about how to store commercial spent fuel over the long term will require making a series of value judgments.

## *Board conclusions and recommendations*

After reviewing about two-dozen technical and nontechnical issues, the Board believes that *it is possible to find the right balance* between disposal and storage. Long-term spent fuel storage needs can be addressed in a way that keeps the goal of repository development on track.

### *Is there an urgent technical need for centralized storage of commercial spent fuel?*

The Board sees no compelling *technical* or safety reason to move spent fuel to a centralized storage facility *for the next few years*. The methods now used to store spent fuel at reactor sites are safe and are likely to remain safe for decades to come. Despite some recent public opposition to utility efforts to develop additional storage, so far, utilities have been able to add new storage capacity at their sites when needed.

### *Will federal storage be needed in the future?*

The Board believes that federal storage capacity *will* be needed *in the future* for two reasons. First, when a repository begins operating, a centralized storage capability will be needed to provide added flexibility to handle the waste. For example, storage would provide a buffer between the repository and the rest of the waste management system if waste emplacement rates in the repository are less than spent fuel acceptance rates. Storage capacity also offers technical advantages, such as allowing spent fuel to be mixed and matched to optimize the thermal loading of the repository to improve repository performance.

Second, commercial spent fuel storage needs will change markedly beginning around 2010. Until then, approximately 15,000 metric tons of new storage capacity will be needed at reactor sites. But beginning around 2010, large amounts of dry-cask storage will be required to allow removal of spent fuel from the storage pools of reactors that are being shut down. It is *at this time* that a federal storage facility operating at full scale will be most useful. A centralized facility will relieve utilities of the need to build new dry-storage capacity at shutdown reactors while accommodating any future institutional or technical uncertainties associated with the long-term storage of spent fuel.

Although currently prohibited by law, there is no *technical* reason why a centralized storage facility (and supporting transportation infrastructure) cannot be constructed prior to repository construction. In fact, because of the lead time needed for planning and development, the Board believes it would be practical to begin *planning* now for a federal storage facility(s) that can achieve full-scale operation (i.e., accept 3,000 metric tons/year) by 2010 when reactors begin shutting down in large numbers.

***Can the right balance be found between meeting future spent fuel storage needs and continuing to pursue permanent disposal?***

*The nation needs both a repository development program and a plan to address future spent fuel storage needs*

In the past whenever there has been a choice between storage and disposal, disposal has always been made the primary focus of the federal high-level waste management program. This is because the storage of commercial spent fuel is not an acceptable substitute for disposal. Ultimately, spent fuel (commercial and defense) as well as sizable amounts of high-level radioactive defense waste will have to be disposed of. The Board believes that the nation needs *both* a repository development program and a plan to address future spent fuel storage needs. However, efforts now to refocus the program from disposal to storage, especially at a time when budgets are tight, could jeopardize site-characterization and repository development efforts in three ways: (1) by competing with the disposal program for resources, (2) by causing a real or perceived prejudicing of a future decision about the suitability of the Yucca Mountain site, and (3) by eroding the impetus and political support for repository development.

Given the stage of the current site-characterization program and the fact that substantial new storage capacity will not be needed until 2010, the Board has concluded that it makes technical, management, and fiscal sense to await the decision on the suitability of the Yucca Mountain site for repository development before beginning development of a federal centralized storage facility. The

Board believes that the following approach *strikes the right balance* between maintaining the national goal of permanent disposal while meeting future storage needs.

- Disposal: The nation has a program for developing a repository for the permanent disposal of spent fuel. So far, no technical reasons have been found for abandoning the site being characterized at Yucca Mountain. The Board believes that if the DOE can maintain the recent pace of underground exploration, testing, and analysis, sufficient information should be available to determine within five years if the Yucca Mountain site is suitable. By *suitable* the Board means that there is a high probability that the site, along with the appropriate engineered barriers, can provide long-term waste isolation. Therefore, *the Board recommends that for the next several years the DOE continue to focus its efforts on evaluating the suitability of the Yucca Mountain site for repository development*.

- Storage: *The Board recommends that generic planning for a federal storage facility and for a supporting transportation infrastructure begin now at a funding level modest enough to avoid competition with the repository program. Development of the storage facility should be deferred until after a decision has been made about the suitability of the Yucca Mountain site* for hosting a repository. Because of the increased advantages of having a storage facility located at an operating repository site, *if Yucca Mountain proves suitable for repository development, the centralized storage facility should be located there*. Activities could begin around 2000 to construct a storage facility that would be operating at full scale by 2010 — at the repository site. Operation by this date would largely eliminate the need to store significant amounts of spent fuel at reactors after they are shut down.

  *Development of the storage facility should be deferred until after a decision has been made about the suitability of Yucca Mountain for hosting a repository*

  *The Board also recommends developing storage incrementally by limiting the amount that can be transported to Yucca Mountain until the repository has been licensed for construction. This will address the potential risks associated with linking storage to the earlier milestone of site suitability, rather than waiting until the NRC licenses the construction of the repository as required by existing law.*

  *The Board suggests planning now for a limited-capacity backup facility, similar to the one previously authorized by the Nuclear Waste Policy Act, for emergency storage to be located at an existing federal nuclear facility. Development of the backup facility should begin only if a clear need for the facility is established.* Its operation should be phased out once operation of a large storage facility at the repository site commences.

The process of licensing and developing a large federal centralized storage facility and the transportation infrastructure that goes with it will take time; estimates range from five to seven years. Even if passed into law now, none of the proposals before Congress would enable operation of a centralized storage facility to begin much before 2002 — and then not at full scale. With the spent fuel stockpile currently at 32,000 metric tons and growing at 2,000 metric tons per year, it will take as long as 30 years to empty the inventory at all the individual reactor sites. So, developing a centralized storage facility at Yucca Mountain now would only *reduce*, but not eliminate, the need to continue adding spent fuel storage capacity at reactor sites. The Board's suggested approach differs from currently proposed strategies only by the time it will take to determine site suitability — at most five years.

*To avoid having substantial amounts of spent fuel sitting at shutdown reactors…2010 is the key milestone*

With respect to storage, 2010 is the key milestone. Being able to accept small amounts of spent fuel in 1998 or 2002 will address the storage concerns of only a few utilities. Being able to accept 3,000 metric tons per year for 30 years beginning in 2010 will be necessary to avoid having substantial amounts of spent fuel sitting at shutdown reactors.

***How should the costs of federal storage be paid?***

Given current funding projections, it appears that the Nuclear Waste Fund will be only marginally capable, at best, of supporting the long-term development and operation of a repository for the permanent disposal of spent fuel. Therefore, the costs of a limited federal storage facility could be recovered through a new fee assessed on the users of that facility. The costs of a large storage facility located at a repository site (which would be used for all spent fuel) could be recovered by increasing the current 1 mill-per-kwh fee going into the Nuclear Waste Fund. This would avoid having the taxpayer bear the costs of final closure of the repository.

***What would it take to implement these recommendations?***

These Board recommendations represent a departure from existing policies. The Nuclear Waste Policy Act currently links development of a storage facility to the construction of a repository. *The Board recommends that development of a storage facility at Yucca Mountain be linked to the earlier decision about the suitability of the Yucca Mountain site as defined above.*

This new approach is not free of risk. Given the inherent difficulties associated with proving safe repository performance over many thousands of years, a site-suitability decision would not be an iron-clad guarantee that the site could be developed as a repository. However, the Board believes that the risks of linking storage to a site-suitability decision, rather than to the NRC licensing decision, can be minimized if the DOE clearly delineates its site-characterization program and focuses on the timely completion of the needed scientific activities *and* if it continues to work closely with the oversight groups (e.g., the NRC) that have been involved thus far with the program. Working closely with these groups can help ensure that the decision about the suitability of Yucca Mountain for repository development is technically sound.

*Successful development of a [waste management] system for the nation… will require sound program management and sufficient and consistent funding*

Finally, successful development of a system for managing the nation's spent fuel and high-level waste will require sound program management and sufficient and consistent funding. Without adequate funding for disposal *and* storage, a significant amount of spent fuel will remain in storage at reactor sites well after large numbers of reactors begin shutting down in 2010.

## *Summary of Board recommendations*

After evaluating various technical and policy-related considerations regarding federal centralized storage, the Board believes that it is possible *to find the right balance* between permanent disposal and temporary storage of commercial spent nuclear fuel.

1. Developing a permanent disposal capability should remain the primary national goal and, for the next several years, determining the suitability of the Yucca Mountain site should remain the primary objective of the DOE's waste management program. Assigning the Office of Civilian Radioactive Waste Management any significant new activities at this time could compete for funding and other resources with site-characterization and repository development efforts at the Yucca Mountain site.

2. The Board recommends that during the next several years *generic* planning for a centralized storage facility and for a supporting transportation infrastructure begin at a funding level modest enough to avoid competition with the repository program. From a technical, operational, and fiscal perspective, 2010 is the key milestone for storage. Therefore, plans should be made to have this storage facility operating at full capacity (able to accept 3,000 metric tons/year for 30 years) by about 2010. This will allow the federal government to remove

the backlog of spent fuel from those plants already shut down and to empty the pools at other plants as shutdowns occur.

3. The *construction* of a federal centralized storage facility should be deferred until after a decision has been made about the suitability of the Yucca Mountain site for repository development. If Yucca Mountain proves suitable, the centralized storage facility should be located there.

4. The Board recommends developing storage *incrementally* by limiting the amount that can be transported to Yucca Mountain until repository construction has been authorized by the NRC. This will address the potential risks associated with linking storage to the earlier milestone of site suitability.

5. The Board also recommends reauthorizing limited-capacity backup storage, similar to the one previously authorized by the Nuclear Waste Policy Act, at an existing federal nuclear facility. *Actual development* of the backup facility should begin only if a clear need for the facility is established. Its operation should be phased out once the operation of a large centralized storage facility commences.

6. Because siting a centralized storage facility may be extremely difficult without a viable disposal program, if the site at Yucca Mountain proves unacceptable for repository development, the Board recommends that other potential sites for *both* disposal and centralized storage be considered.