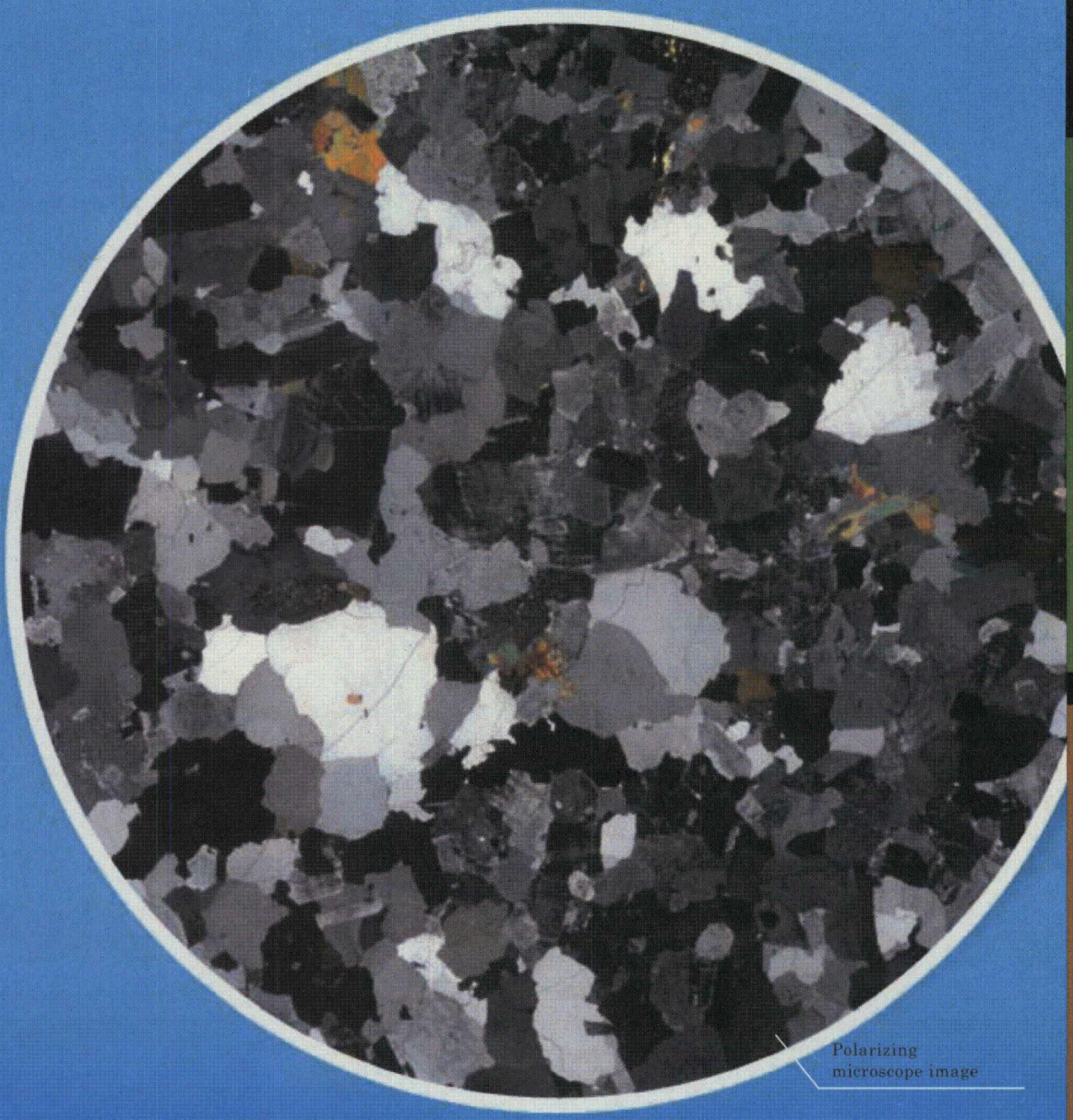


Polarizing
microscope image

Geoscience

Japan Atomic Energy Agency

Tono Geoscience Center

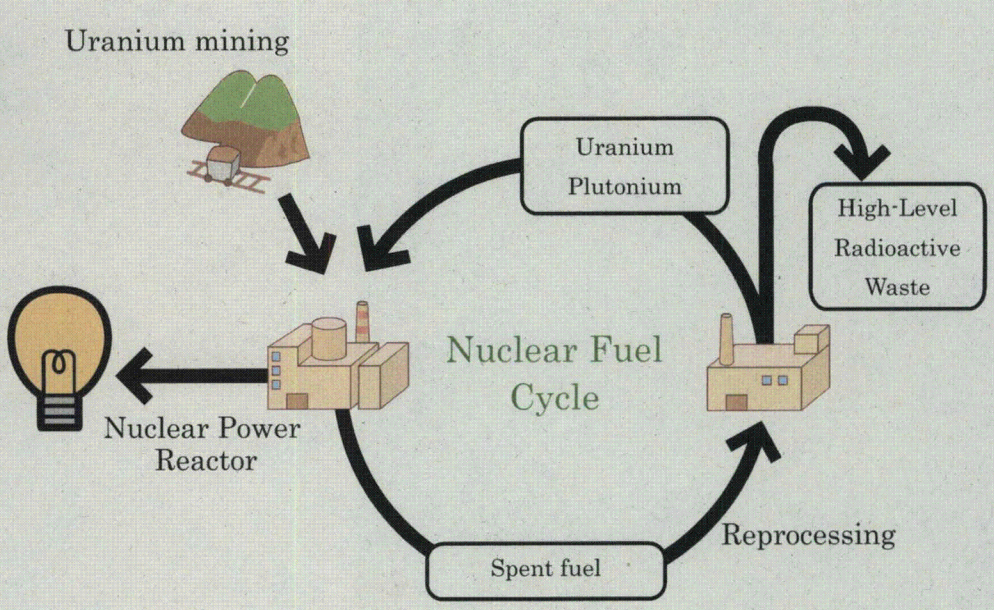
Tono Geoscience Center carries out a wide range of Geoscientific Research

The Japan Atomic Energy Agency (JAEA) is engaged in a research & development (R&D) program for the safe Geological Disposal of High-Level Radioactive Waste (HLW). HLW is produced after the extraction of re-usable materials from spent nuclear fuel arising from electric power generation using nuclear energy. Nuclear energy provides the base load electrical power for Japan's energy needs.

For the R&D related to Geological Disposal of HLW, Tono Geoscience Center (TGC) has been conducting research into deep underground environments (Geoscientific Research). The aim of this research is to establish methodologies and techniques needed for the characterization of underground environments.

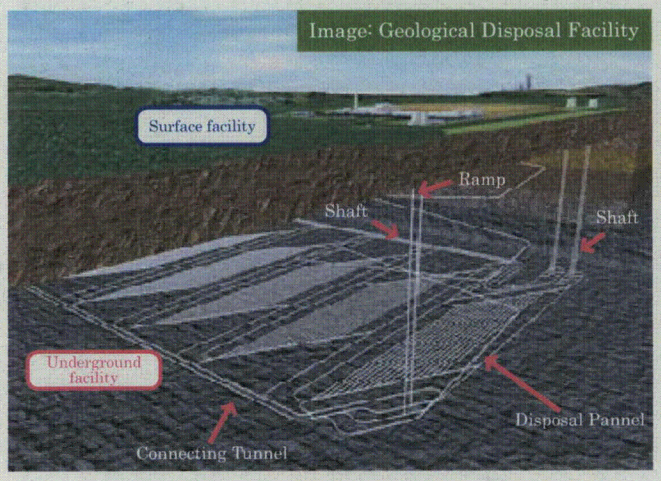
What is the Geological Disposal of HLW?

The spent fuel from nuclear power generation is chemically processed at a fuel reprocessing plant for re-use as new fuel. Uranium and plutonium are recovered and recycled as fuel for the generation of electricity. The cycle shown on the right is known as the "Nuclear Fuel Cycle." Establishment of the "Nuclear Fuel Cycle" is the fundamental policy for nuclear energy development and utilization in Japan.



- High-Level Radioactive Waste (HLW) produced by the reprocessing of spent nuclear fuel is highly radioactive. Though the radioactivity decays with time, the HLW continues to release radiation for an extremely long time. Therefore, it is necessary to isolate the HLW effectively from the human environment for tens of thousands of years. A variety of methods for disposal of HLW have been considered internationally. However, geological disposal is universally seen as the most promising method because of its technical feasibility. HLW will be placed in a repository, at a depth of at least 300m. The concept for Geological Disposal of HLW is outlined by the "Designated Radioactive Waste Final Disposal Act".

Image: Geological Disposal Facility



by Nuclear Waste Management Organization of Japan

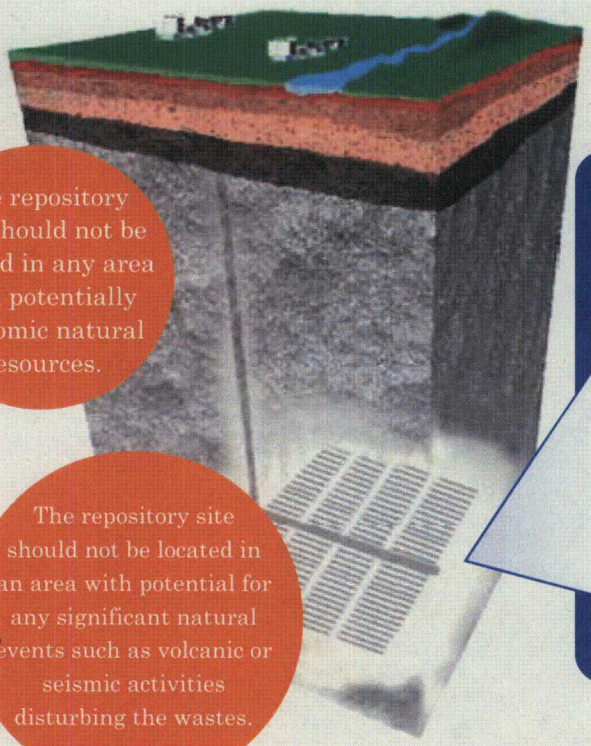
Assuring safety of Geological Disposal

Could a human being disturb the radioactive waste while mining natural resources such as coal and oil?

The repository site should not be located in any area with potentially economic natural resources.

Could the radioactive waste be uplifted to the surface due to volcanic or fault activities?

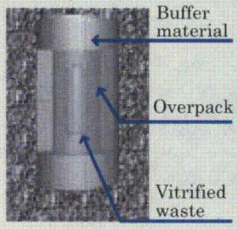
The repository site should not be located in an area with potential for any significant natural events such as volcanic or seismic activities disturbing the wastes.



Could the radioactive waste leak into groundwater and migrate to our environment?

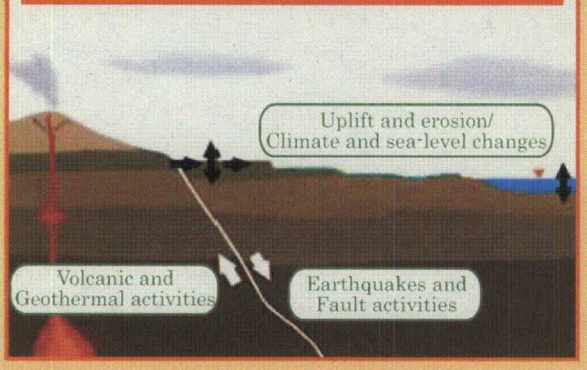
To prevent this the waste will be isolated by

1. Engineered barriers and

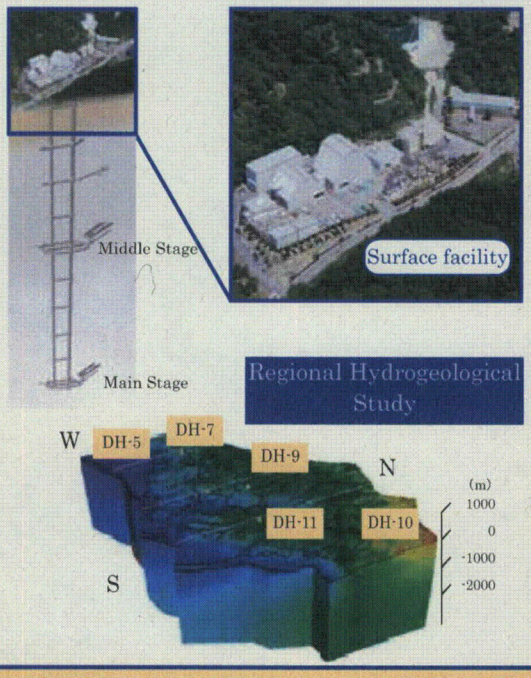


2. Natural geological barriers

Study on the long-term stability of geological environment



Mizumani Underground Research Laboratory(MIU) Project



Regional Hydrogeological Study

Geoscientific Research at Tono Geoscience Center

Facilities of Tono Geoscience Center

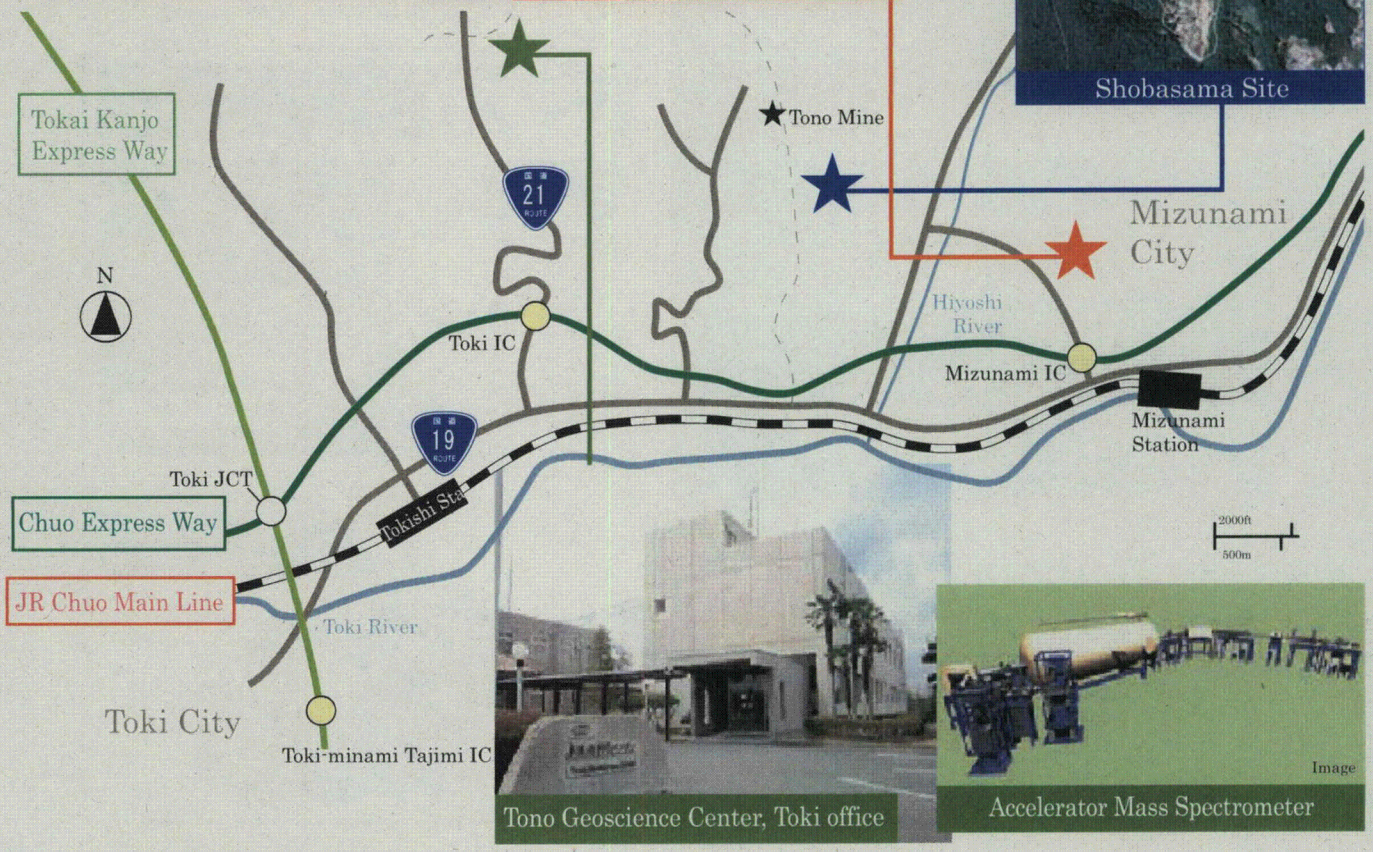
Mizunami Geoscience Academy

MIU Construction Site

Mizunami International Geoscience Community Plaza

MIU Office

Shobasama Site



Tono Geoscience Center, Toki office

Image
Accelerator Mass Spectrometer

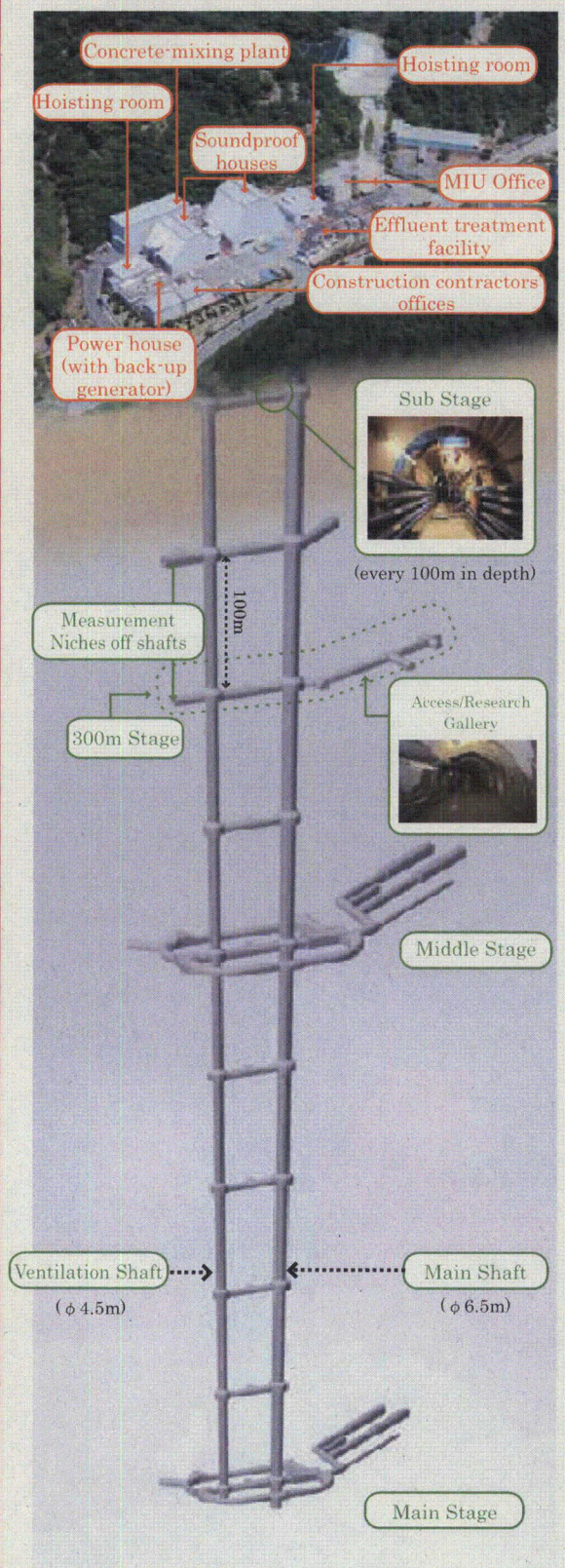


Image: Mizunami Underground Research Laboratory

※Location and length given here may be changed due to geological environment and construction condition.

History of Tono Geoscience Center

1962 Discovery of uranium mineralization in an outcrop along the former National Route 21 by the Geological Survey of Japan

1965 Establishment of the Tono Exploration Office by the Atomic Fuel Corporation (PNC's predecessor) in Toki City
※PNC= Power Reactor and Nuclear Fuel Development Corporation

1973 Complete excavation of the Exploratory Shaft in the Tono Mine

1986 Commence Geoscientific Research

1991 Complete excavation of the No.2 Shaft in the Tono Mine

1992 Commence the Regional Hydrogeological Study

1995 Conclude the Agreement on the Underground Research Laboratory Project with Gifu Prefecture, Toki City and Mizunami City (December 28th)

1996 Commence the Mizunami Underground Research Laboratory Project

1998 Reorganize PNC to JNC (Japan Nuclear Cycle Development Institute)

2002 Conclude the 'Lease Contract' and 'Agreement associated with the lease contract' for Mizunami City-owned land (January 17th)

Commence construction of the Mizunami Underground Research Laboratory (July)

2003 Commence excavation of the Main and Ventilation Shafts at the MIU Construction Site (July)

2004 Complete Geoscientific Research at Tono Mine (March)

Suspension of business at Tono Mine

2005 Merger of the Japan Nuclear Cycle Development Institute (JNC) and the Japan Atomic Energy Research Institute (JAERI) to form the Japan Atomic Energy Agency (JAEA)

Conclude the "Environmental Preservation Agreement related to Mizunami Underground Research Laboratory" with Gifu Prefecture and Mizunami City (November 14th)

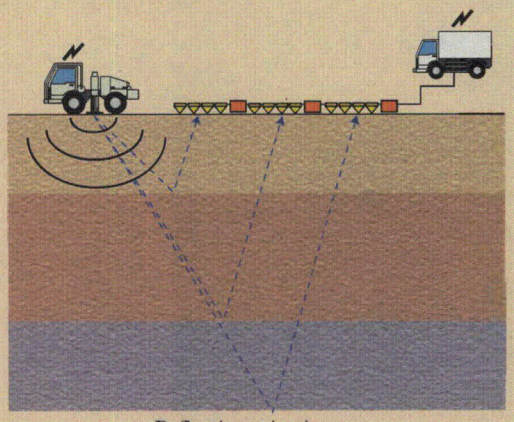
Geoscientific Research

Mizunami Underground Research Laboratory (MIU) Project 1

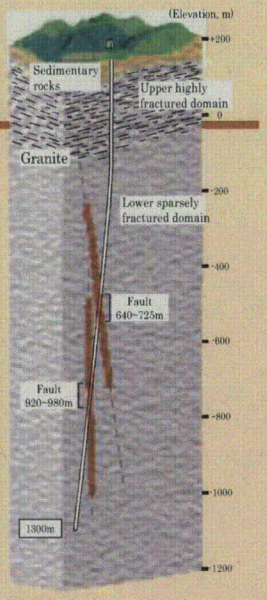
Tono Geoscience Center has been conducting a wide range of geoscientific research. In this project, the aim is to establish the technical basis for investigation and analysis of the geological environment and to develop engineering techniques for deep underground application. The research started at the JAEA owned Shobasama Site in 1996. Since 2002, the research has been carried out mainly at the MIU construction site on land owned by Mizunami City.

Phase I Surface-based Investigation Phase

In Phase I, geological, hydrogeological, hydro-geochemical and rock mechanical characteristics of the bedrock have been investigated by borehole investigations, surface geophysical surveys etc. Site descriptive models have been constructed using the data obtained during Phase I. The Phase I investigation was completed in 2004.



Reflection seismic survey



Borehole investigation

Phase II Construction Phase

The methodology for modeling and investigation employed in Phase I has been assessed based on the data obtained during the construction of underground research laboratory. Furthermore, changes to the geological environment in response to excavation of the shafts has been actively monitored.

Fracture mapping

Phase III Operation Phase

During Operation Phase, various kinds of in situ experiments will be carried out in the research galleries.

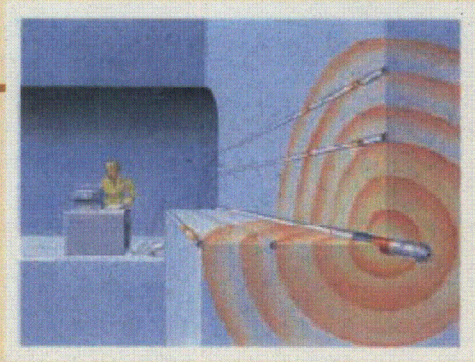
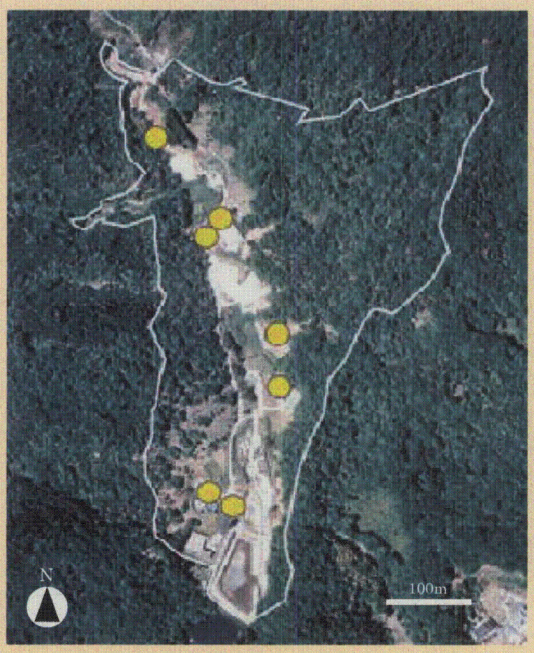


Image: Research on the effects of heat on geological environment

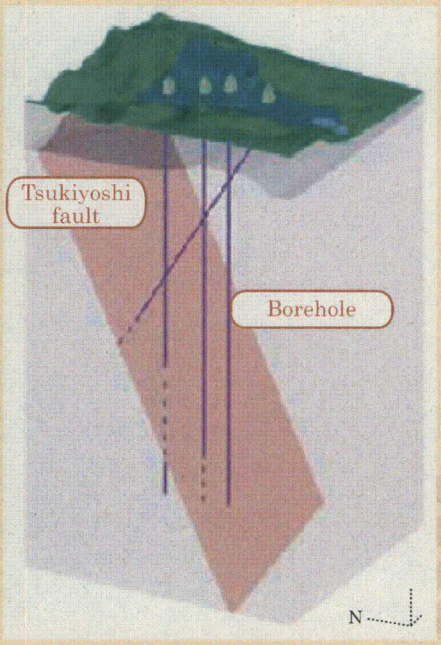
Under the land lease contract concluded with Mizunami City in 2002, the city-owned land will be leased for a period of 20 years. After completion of the Geoscientific Research, the shafts would be backfilled and the land would be returned to the city. However, due to a request from Mizunami City, the MIU facility might be reused. The "MIU Site Reuse Committee" was established to discuss future use of the MIU Site with local communities and experts.

Geoscientific Research at the Shobasama Site

The Tsukiyoshi fault intersects the granite at the Shobasama Site. The effect of this fault on groundwater flow has been investigated at the Shobasama site.



Borehole

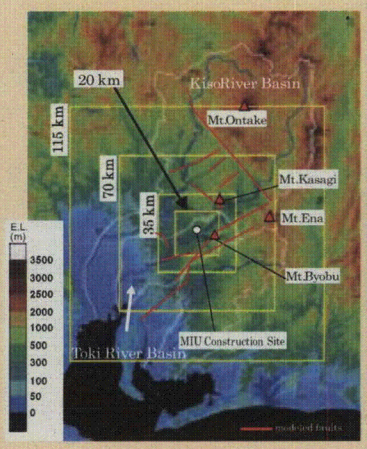


Regional Hydrogeological Study (RHS) 2

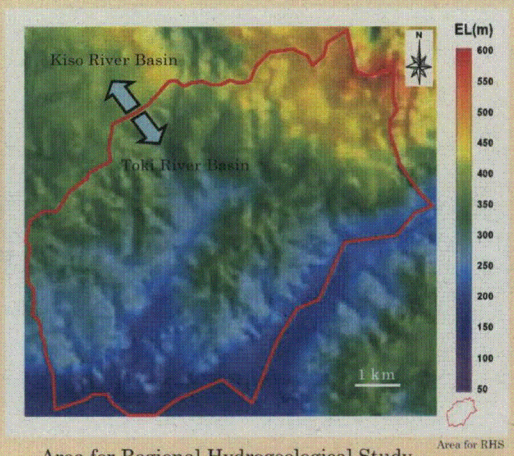
A regional hydrogeological study has been carried out to establish appropriate methodologies for the hydrogeological investigations, groundwater flow analysis and for determining the distribution of groundwater chemistry in and around the Tono area. In addition, the technologies needed to assess the appropriateness of the methods have been acquired.

Research, such as borehole investigations, was executed from 1992 to 2003. Currently, long-term monitoring of groundwater pressure is in progress.

It is understood that groundwater flow in the 35 km x 35km study area in Tono is 1) influenced by topography and structural discontinuities and 2) groundwater flow less than approximately 2000m depth is recharged from the ridge separating the Toki and Kiso Rivers and discharged to the Toki River. The study area (right figure) was selected based on this understanding.



Area for groundwater flow modeling on regional scale and modeled faults

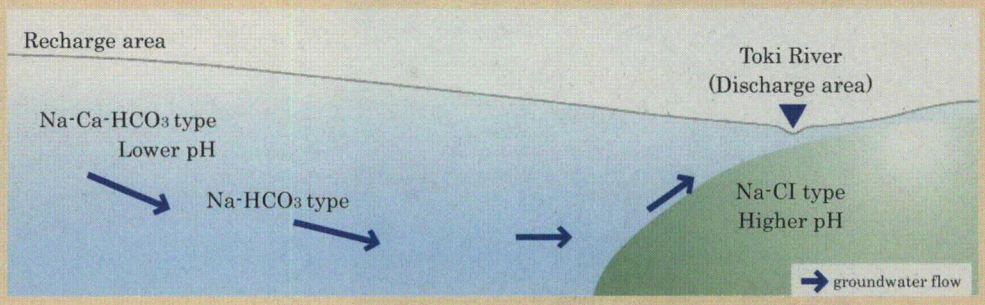


Area for Regional Hydrogeological Study

Groundwater flow was analyzed using data from seismic surveys, airborne geophysical surveys and borehole investigations. The results of the groundwater flow analyses are consistent with the groundwater flow predicted from the variations in groundwater chemistry.

It is understood that 1) borehole investigations aligned along groundwater flow directions are effective in evaluating the results of groundwater flow modeling and 2) it is of fundamental importance to investigate faults, the major structures that cross groundwater flow paths.

※The groundwater chemistry and the pH changed from Na-Ca-HCO_3 type to Na-HCO_3 type due to water-rock interactions along the flow path.



Schematic view of groundwater chemistries and groundwater flow

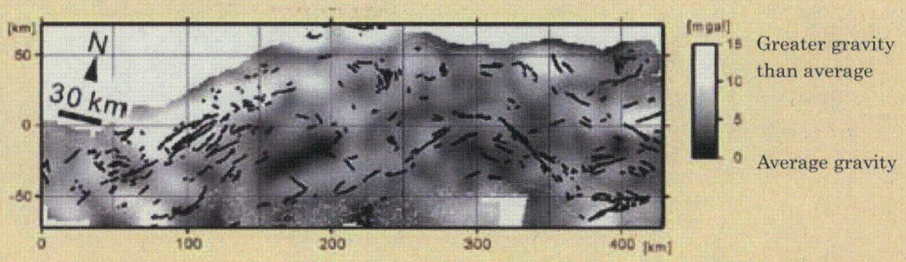
Study on the long-term stability of the geological environment 3

The Japanese Islands are situated along the Circum-Pacific orogenic belt characterized by active tectonism, manifested by abundant seismic and volcanic activity. The characteristics and effects of crustal movement and volcanism are being studied through various case studies in order to establish methodologies to assess the long-term stability of the geosphere.

Study on seismicity and faulting

As an example, there is a study investigating active faults, including faults believed to have activated repeatedly over hundreds of thousands of years without fault trace emerge on the ground surface.

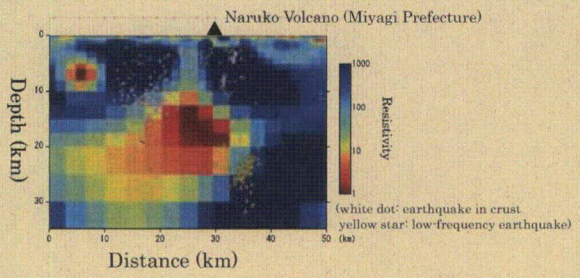
The image below shows that gravity anomalies are in good agreement with active faults and lineaments on ground surface. As a result, it is considered that analysis of gravity anomalies can have practical application in the investigation of active faults.



Comparison of a reading of gravity corrected for altitude and active faults or lineament

Study on volcanism and geothermal activity

There is also a study on the methodology for detection of magma and related thermal structures in the deep crust. The image below shows observations obtained by the 'Magnetotelluric method', which is used to survey electrical resistivity structure in the crust. The maximum depth of crustal earthquakes is coincident with the upper boundary of a low-resistivity zone, so it is deduced that the low-resistivity zone represents magma and/or related high-temperature fluids. Based on this, it is concluded that the 'Magnetotelluric method' can be effective tool for detecting magma and high-temperature fluids deep underground.



Study on uplift, denudation, climatic and sea-level changes

Another study is underway to develop a methodology to understand topographic changes with time. The images below provide an example of a computer analysis of the results. The changes are calculated assuming that the balance between sediment inflow and sediment outflow volumes causes the topographic changes. Using visual images like these is considered practical for explaining/demonstrating topographic change in the future.

Current Topography

Analysis of Topography 120,000years later

Safety Management and Environment Management

During the Geoscientific Research, and excavation of the shafts and research galleries at the MIU construction site, priority will continue to be given to safety as well as maintaining the integrity of the surrounding environment. In addition, based on the "Environmental Preservation Agreement related to the Mizunami Underground Research Laboratory", the results of groundwater analysis are regularly reported to the local government and are openly available through JAEA's website.

Regarding Tono Mine, although the mine was discontinued after completion of research, maintenance of the facility has been continued.

International Collaboration and Technical Cooperation

Collaboration with international institutes and researchers is being pursued to develop advanced technologies, to enhance safety management and to promote more effective research. Furthermore, collaborative research and joint use of the underground facility with other Japanese research institutes and universities, such as Tono Research Institute of Earthquake Science, Association for the Development of Earthquake Prediction, are being promoted.

Public Relations and Disclosure of Information

For enhancing the understanding of Tono Geoscience Center's work as well as for the understanding of nuclear energy in general, Tono Geoscience Center has made considerable effort to maintain contact with communities through participation in local events and providing educational seminars and MIU facility tours.

Furthermore, various research reports are provided to the public on JAEA's website. People can see the current status of the facility in photos and on the live videos via the website.

Community Events

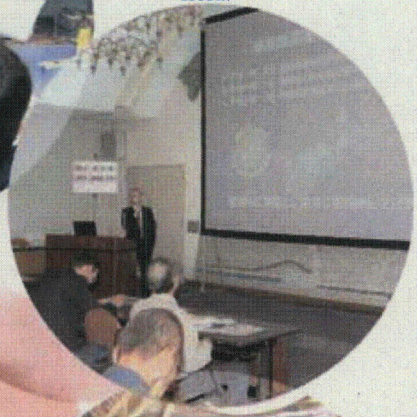
Active participation in community events to introduce our R &D activities to enhance the general public's understanding of JAEA's Geoscientific Research.

Information and Opinion Exchange Conference

Introducing our research status, results and scope to researchers from various universities, research institutes and companies for information exchange and sharing opinions.

Seminars

Holding seminars by invited experts from the geoscience field.



Mini Gallery at Mizunami International Geoscience Community Plaza

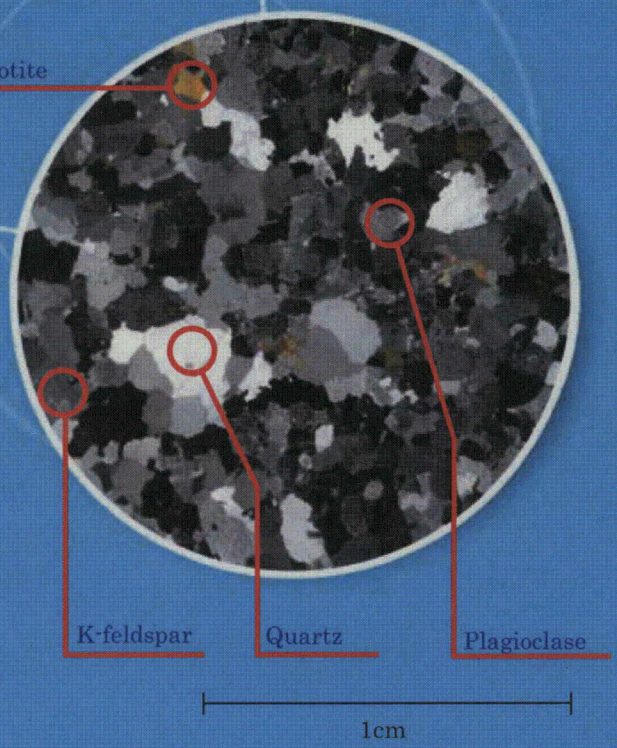
Providing exhibition space for the local community, craft workers can display their artwork, such as paintings, photos and flower arrangements. Application to use the space is always welcome!

MIU Facility Tour

Tours of the MIU underground facilities are conducted regularly. Advance reservations are required. Please contact MIU office for more information.

MIU Information Corner

JAEA brochures, data and reports are available to enhance the people's understanding of JAEA's activities. Photocopying is available.



A photomicrograph of granite from 600m underground, collected during a borehole drilling investigation at the Mizunami Underground Research Laboratory.

Tono Geoscience Center

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FAX : +81-572-68-7717

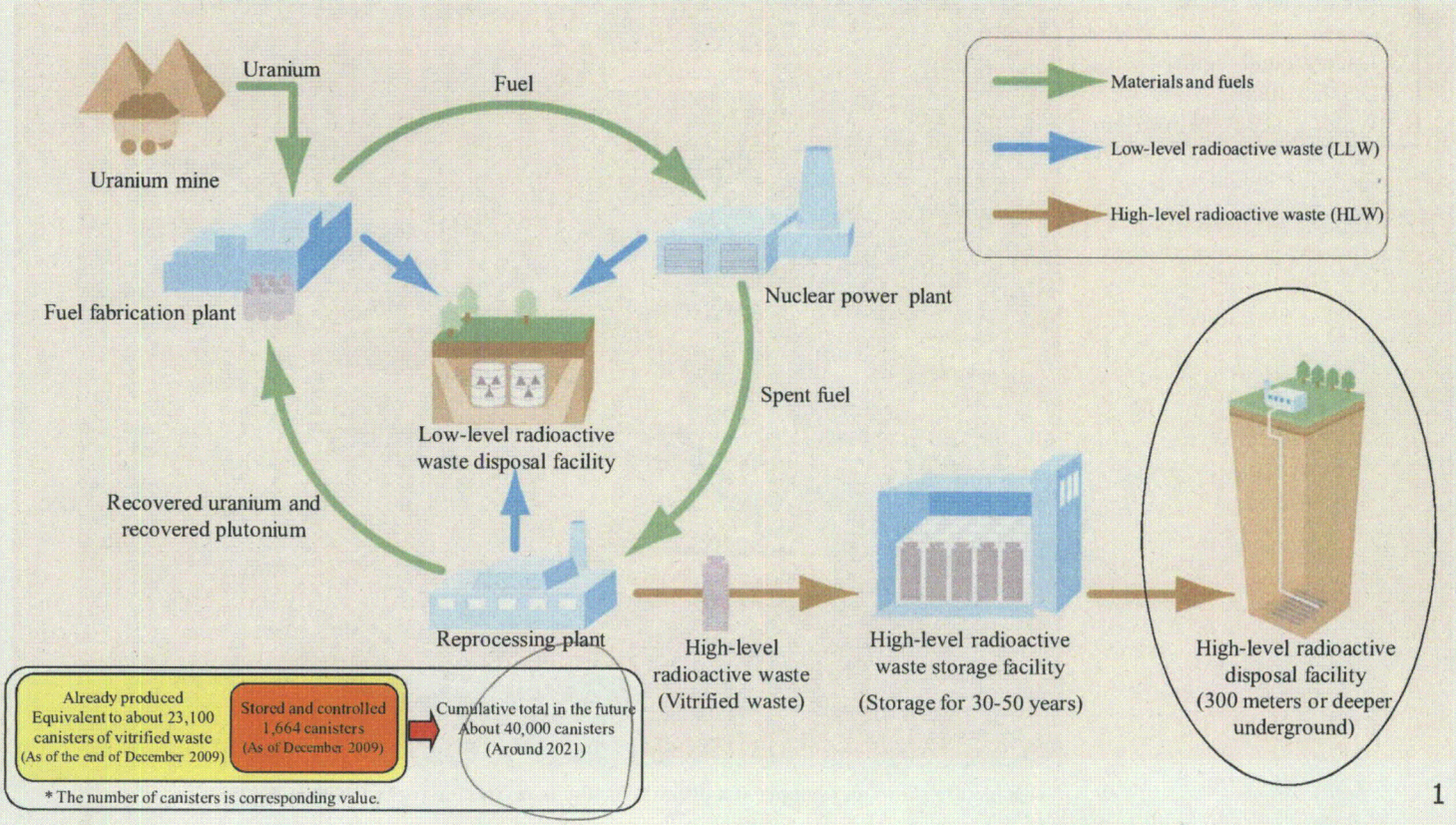
http://www.jaea.go.jp/04/tono/index.htm

Activities for Geological Disposal of Radioactive Wastes in Japan

May 28, 2010
Agency for Natural Resources and Energy

Nuclear Fuel Cycle in Japan

○ Japan's basic policy is to promote the nuclear fuel cycle.
(Policy to recover resources from spent fuels through reprocessing and recycle them, and reduce radioactive wastes)



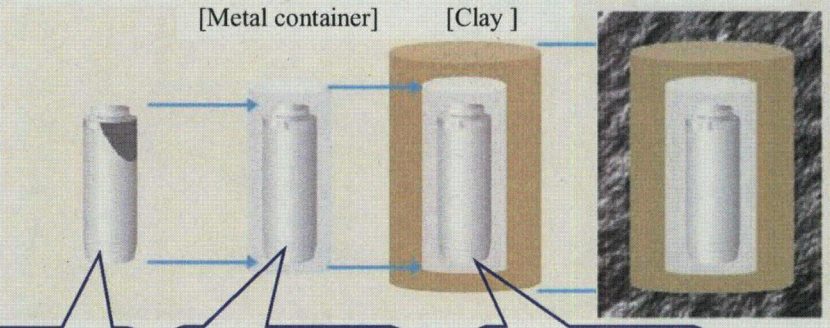
Geological Disposal -- Containment

○ Radioactive substances are contained by combining a stable geological formation (natural barrier) deep underground and multiple engineered barriers to sufficiently reduce the effect on the living environment of human beings.

Multi-barrier system

Engineered barrier + **Natural barrier**

Barrier 1	Barrier 2	Barrier 3	Barrier 4
Vitrification	Overpack [Metal container]	Buffer material [Clay]	Rock



To prevent elution of radioactive substances into groundwater

About 20-cm thick carbon steel container. Reliable isolation from groundwater for 1,000 years.

About 70-cm thick clay barrier. Movements of groundwater and radioactive substances are retarded.

High-level radioactive waste disposal facility

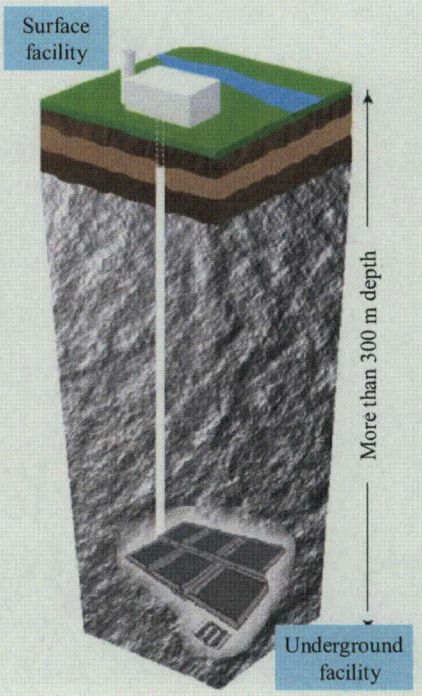
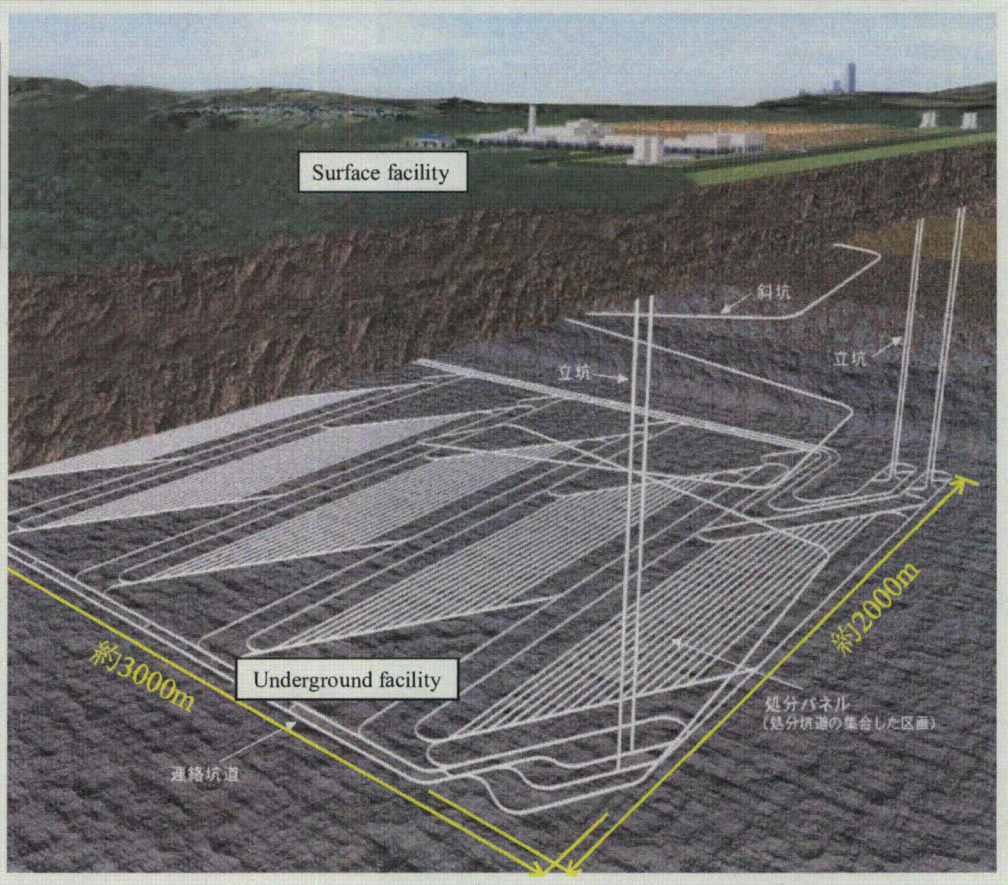


Image of a repository for co-location disposal of high-level radioactive wastes

○Surface facility
Area : about 1km^2

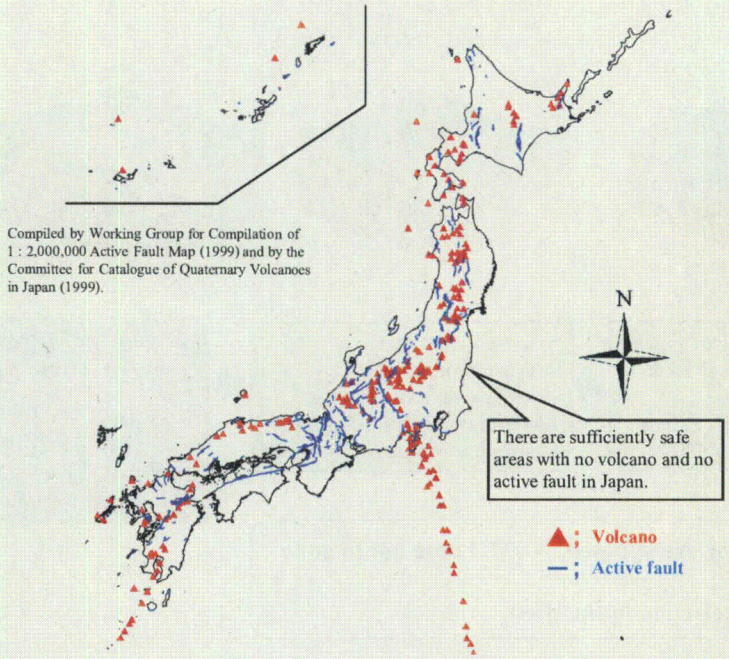
○Underground facility
Depth : 300m ~
Width : about 2km * 3km

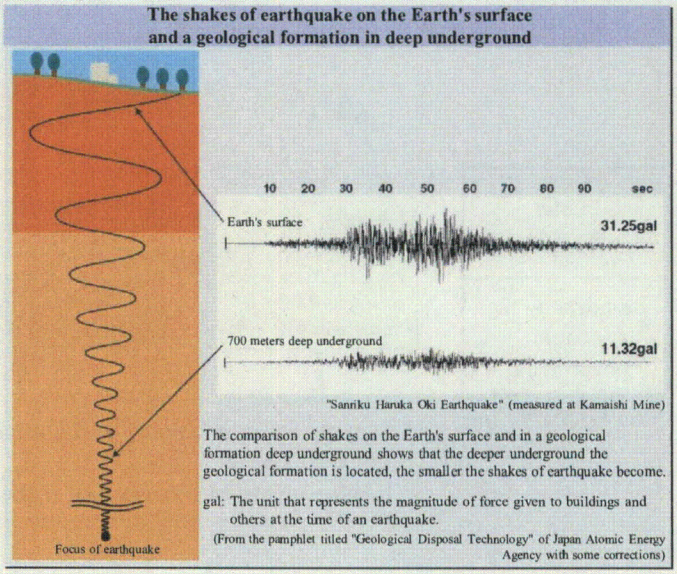


*This picture shows an example of a disposal facility in crystalline rocks (1,000 m depth)

Geological Disposal -- Selection of Stable Geological Environment

Avoidance of volcanoes and active faults





● Distribution of volcanoes and active faults in the Quaternary

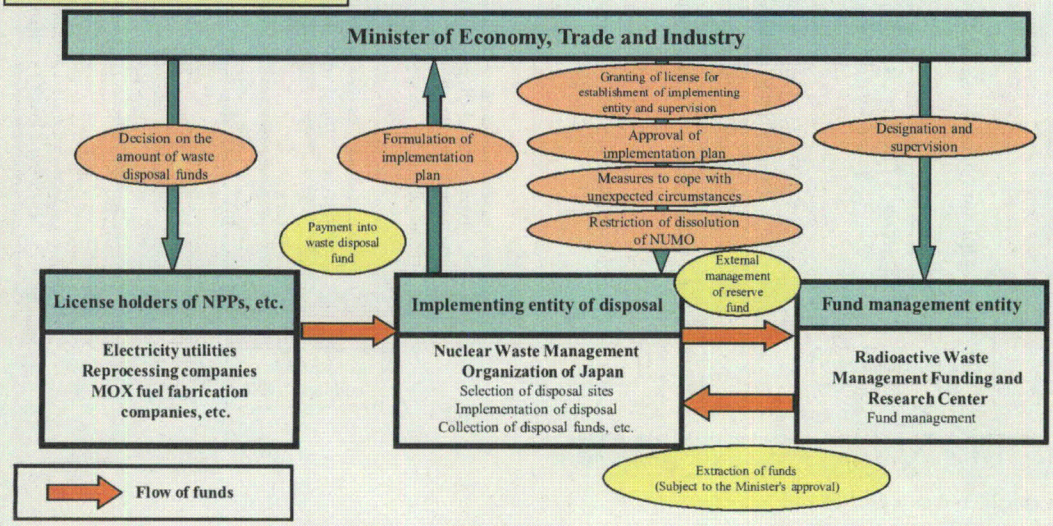
- Effected areas of volcanic activities are limited.
- Fault activities repeatedly occur in active fault zones.
- The shakes of earthquake are small in underground facilities.

Outline of Specified Radioactive Waste Final Disposal Act

1. Major developments

May 2000	The "Specified Radioactive Waste Final Disposal Act" (Final Disposal Act) was enacted.
September 2000	The basic policy and the final disposal plan were decided by the Cabinet (the final disposal plan was revised in October 2005).
October 2000	The establishment of "Nuclear Waste Management Organization of Japan (NUMO)" was approved as the implementing entity of disposal.
December 2002	NUMO started open solicitation for candidate sites from municipalities throughout Japan for the literature survey as the first step of investigations.
June 2007	The Final Disposal Act was revised and TRU wastes and others were added to the types of wastes subject to geological disposal.

2. Basic scheme



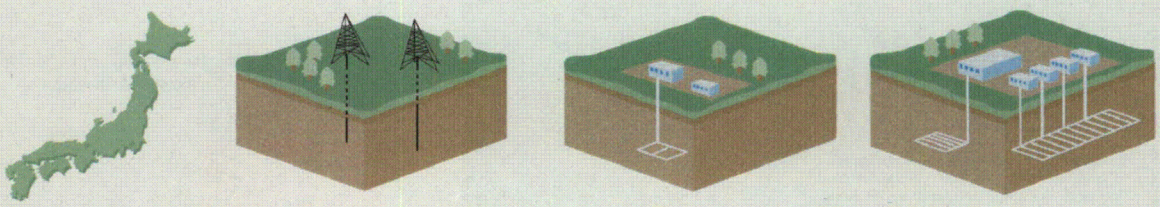
transparency

Status of funds reserved for final disposal

[Total cost of disposal project]
About 3 trillion yen (for about 40,000 units of high-level radioactive wastes)

[Balance of reserve]
About 580 billion yen
(As of the end of March 2008)

Outline of Disposal Site Selection Process



Public solicitation

Proposal by the central government

→ Selection of preliminary investigation areas based on the literature survey※

→ Selection of detailed investigation areas based on the preliminary investigation investigation by boreholes around 2013※

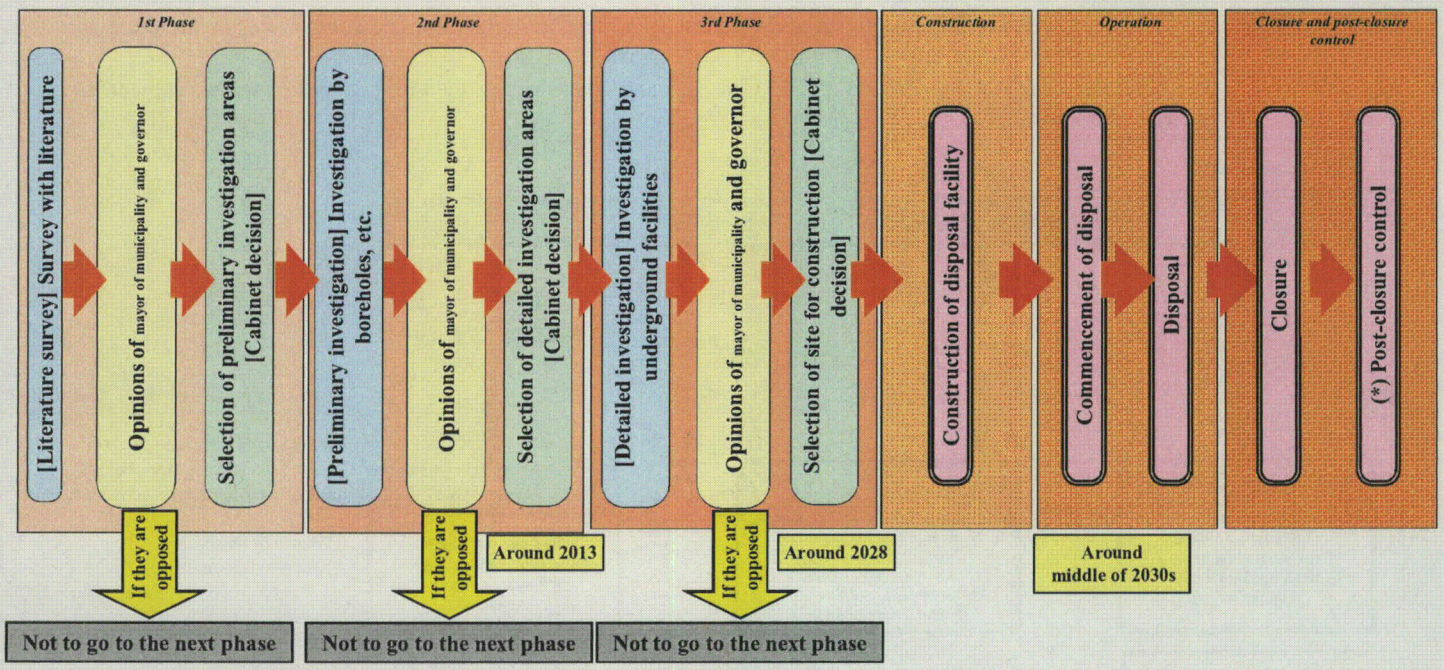
→ Selection of site for construction detailed investigation based on the investigation by underground facilities around 2028※

→ Construction of disposal facility
↓
Commencement of disposal
(Around middle of 2030s)

※ If mayor of municipality and governor are opposed, NUMO dose not to go to the next phase.
※ Cabinet decision is necessary at the selection of the sites.

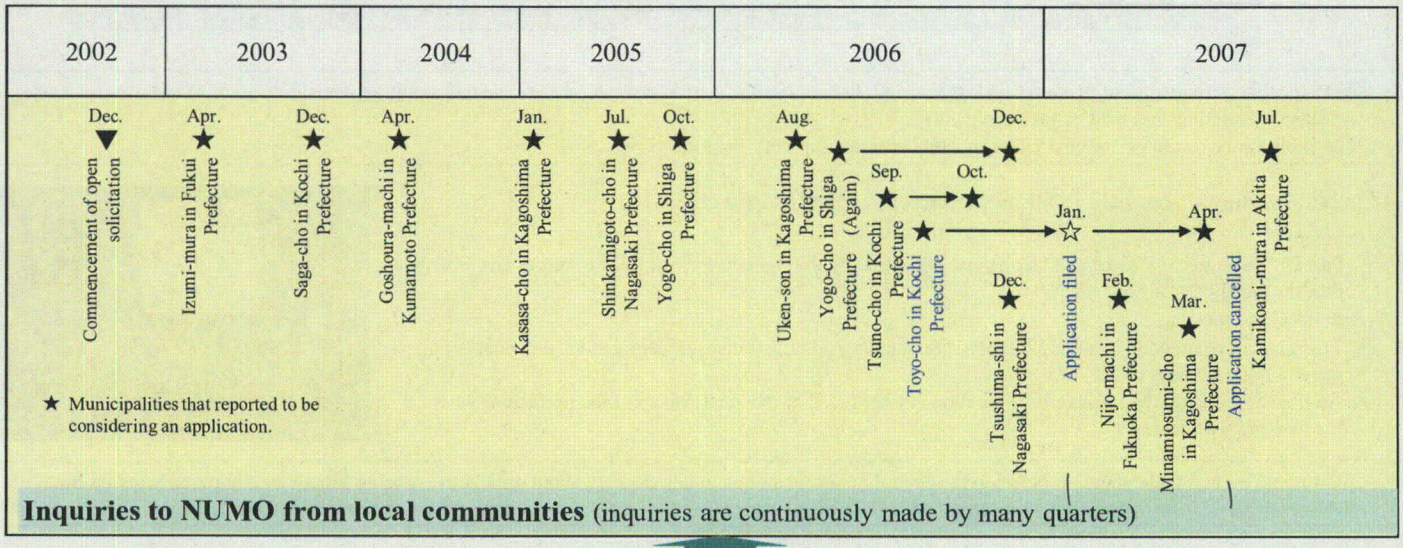
Outline of Disposal Site Selection Process

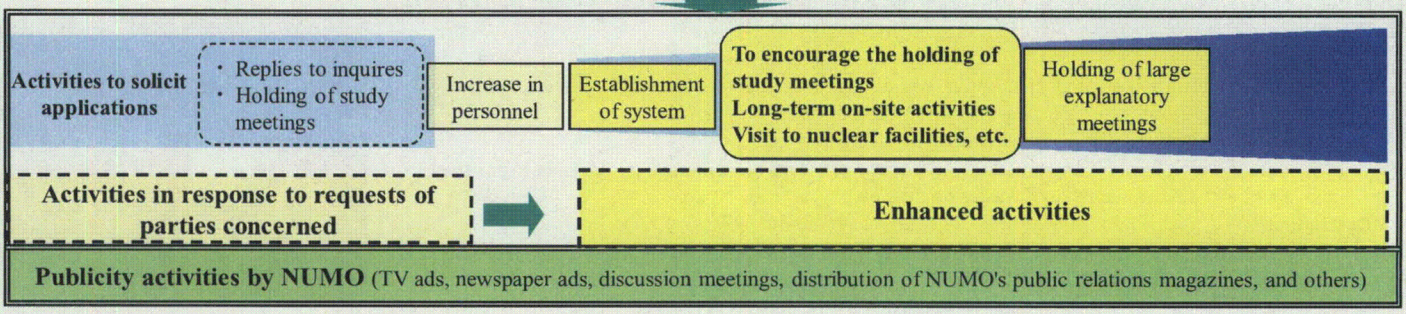
○ The disposal site is selected by step-wised process with three phases.
○ For the selection of preliminary investigation areas, detailed investigation areas and site for constructing a repository, Minister of Economy, Trade and Industry will ask for opinions of a governor and mayor of municipality, and will not proceed with the selection, if they are opposed.



* Three hundreds years are considered as a post-closure management.

Consideration for Applications made by municipalities, to Date





Measures for Reinforcement to Promote Disposal Project

Interim Report of Radioactive Waste Subcommittee, Nuclear Energy Subcommittee, Advisory Committee for Natural Resources and Energy Electricity Industry Committee (1st Nov. 2007)

○ Though there are some municipalities that have expressed their interest in the disposal project such as Toyo-cho in Kochi Prefecture, the literature survey has not yet commenced.

○ In consideration of the developments and others in the areas where applications were considered, the following challenges are found: ① to gain broad understanding of the people until each one of them regards the project as his or her own problem; ② to gain understanding of people in local communities concerning the safety of disposal, procedures for selection of disposal site and others by providing accurate information; ③ to promote efforts by the central government; and ④ to clarify the possibility of regional development through coexistence between the disposal project and local communities.

Measures for reinforcement of activities

1. Reinforcement approach to proceed with the literature survey

○ **Expansion of PR to the general public**
- PR to mass media concerning the necessity of the final disposal project, etc., an explanatory meeting in each prefecture, grass roots activities, and others.

○ **Improvement of regional PR**
- A series of activities to promote understanding about the safety of final disposal, procedures for selection of disposal site, regional development and others.
- Provision of basic geological information

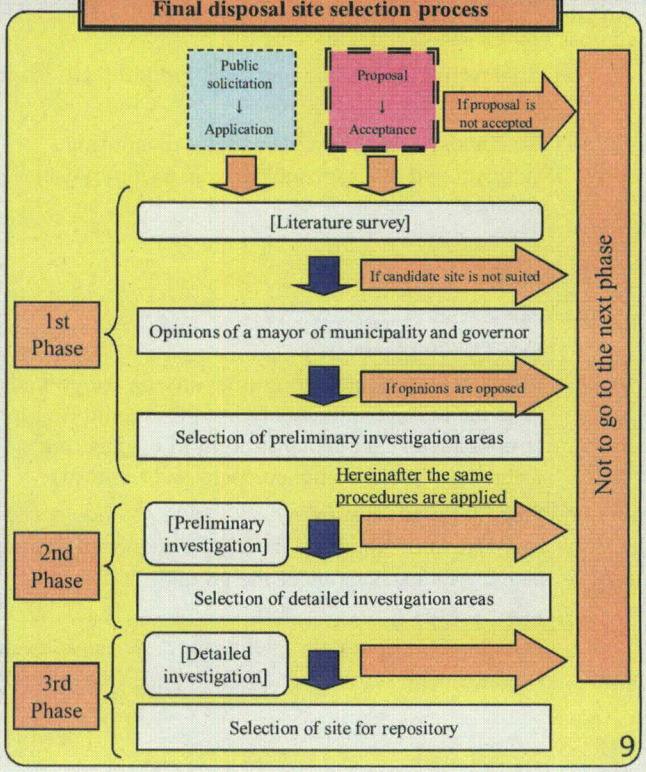
○ **Efforts by the central government**
- Addition of proposal by the central government for implementation of literature survey by considering opinions of local communities, in addition to public solicitation.

2. Presentation of ideas of regional development
○ Presentation of ideas of regional development to coexist with the final disposal project (measures for broad-based regional development, including prefectures)
○ Presentation of measures for utilization of grants in the investigation phases

3. Promotion of research and development and international cooperation to contribute to the understanding of the people
○ Equipment to allow people to experience geological disposal on a simulated basis and virtual repository that utilizes simulation technology.
○ Research and development to improve safety and reliability
○ International cooperation

4. Reinforcement of systems and functions by the central government, NUMO and electricity utilities

Final disposal site selection process



Explanatory Meeting on Geological Disposal of Radioactive Wastes
Workshop on Radioactive Wastes

- As part of the activities to promote mutual understanding between the central government and people about geological disposal of radioactive wastes, explanatory meetings are held in each prefecture.
- The explanatory meetings are held under the joint sponsorship with the local papers.

47 public meetings were held in all prefectures in Japan (as of Feb. 2010)

○ Program
- Part I: "Radioactive Wastes and Geological Disposal" by the Agency for Natural Resources and Energy
  Part II: Panel Discussions among:

○ Description of meeting
- The meeting is attended by about 200 persons including administrative officers and local residents in general in each prefecture.
- After each meeting, the results of the meeting is introduced in the local papers of the prefecture where the meeting was held.

- To promote mutual understanding between the central government and local residents about radioactive wastes, local workshops participated by residents are held in cooperation with groups such as NPOs and others that are engaged in nationwide and regional activities.

Holding 33 workshops which accept local residents' cooperation with NPOs (as of March 2010)

○ Program
<Morning>
- Lecture on "Nuclear Energy and Radioactive Wastes" by the Agency for Natural Resources and Energy

<Afternoon>
- Workshop, Let's Talk Together about "Wastes of Electricity"
  In cooperation with local NPOs and others, two-way workshops to encourage participants to positively think about and discuss the issue of wastes on their own were held.

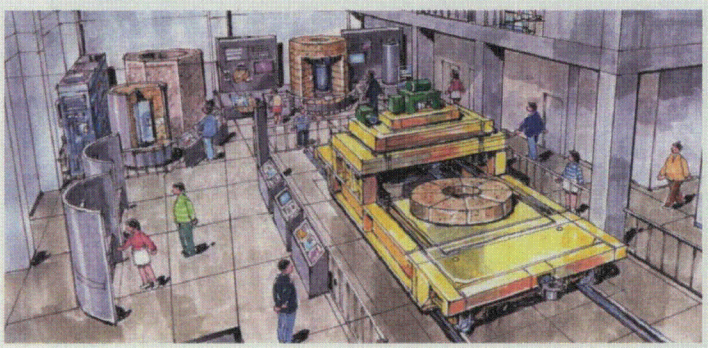
○ Description
- The each workshop was attended by about 50 persons from NPOs, local governments, businesses, universities and media.
  The general meeting for summarization was attended by the persons concerned such as NPOs and other groups who participated in the workshops as staffs in the areas where the workshops were held.

Mock-up Facility for Demonstration of Geological Disposal Concept

[Outline of project]

- To install the demonstration facility and understand the concept of geological disposal, the engineering feasibility and long-term behavior by using it as a Public Acceptance tool.
- To develop the surface and underground facilities in a step-by-step manner.
- To demonstrate the emplacement, monitoring, retrieval and other technologies in a step-by-step manner.

Demonstration facility on the ground



[Development of project]

✓ Step ① [2008 onward]
Installment of demonstration facility on the ground (The facility is continuously used for monitoring long-term behavior and demonstration of engineering technology such as emplacement and retrieval)

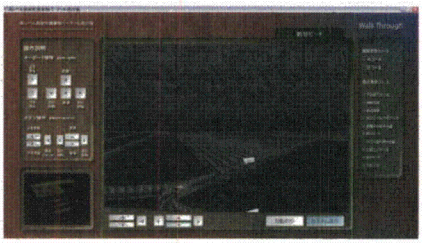
✓ Step ② [2010 onward]
Installment of Mock-up facility for demonstration of engineered barriers under the ground

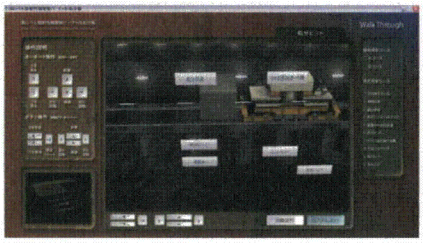
✓ Step ③ [2013]
Installment of mock-up facility for demonstration of emplacement, retrieval and others under the ground

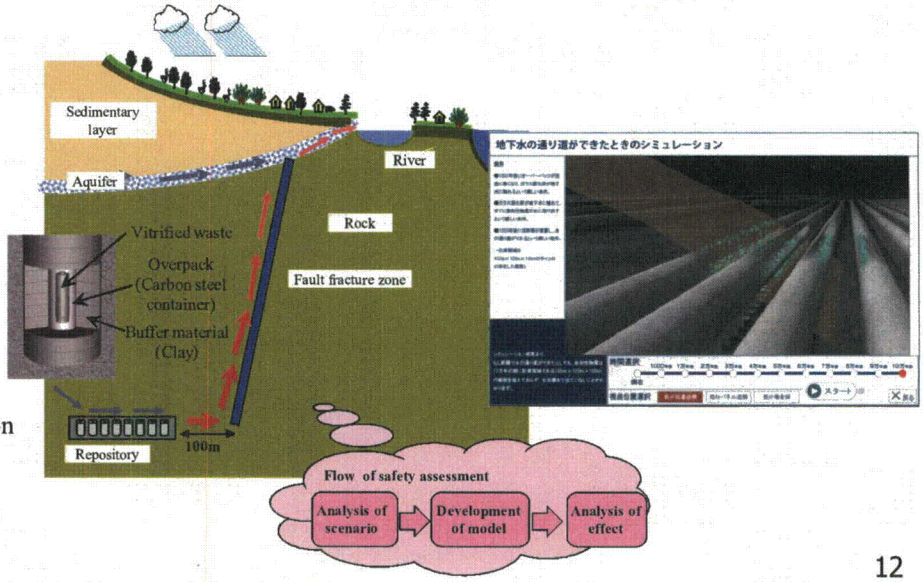
Long-Term Safety Visualization Tool (Virtual Repository)

[Outline of project]

- Image of repository:3D simulation for operation, closure up to long-term safety assessment
- Introduction of real and fine visualization technology based on the results of the latest research
- Creation of multiplatform realizing interactive communications and explanation for a wide variety of people, ranging from the general public to experts
- Use of the above as Public Acceptance tools such as videos, scientific TV programs and others



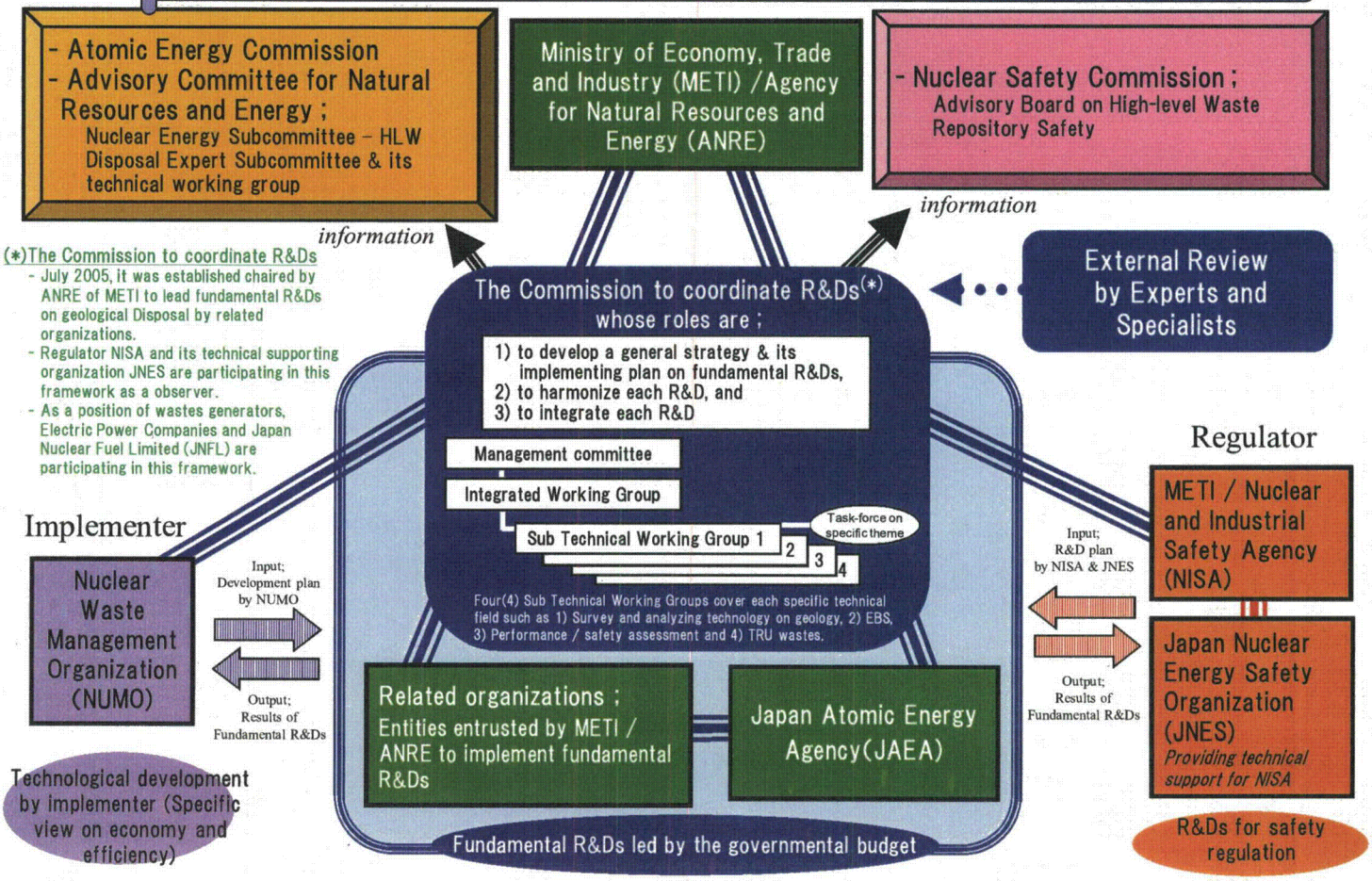




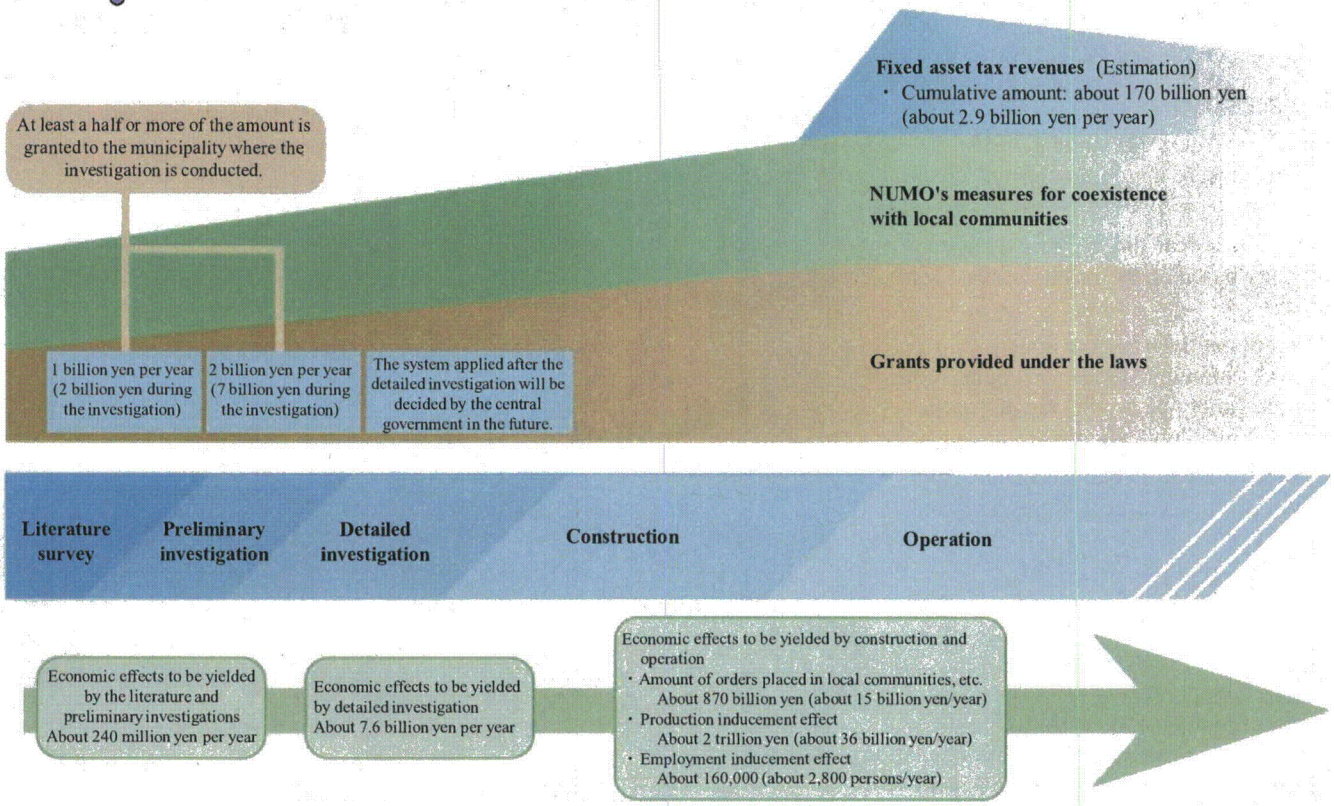
[Development of project]

- ✓ Step ① [2008 onward]
  Creation of prototype visualization tool (Visualization of basic functions and simulation result based on existing safety assessment)
- ✓ Step ② [2010-2011]
  Expansion of variety of safety assessment and visualization technology

Implementing framework on Fundamental R&Ds for Geological Disposal



Progress of Disposal Project & Regional Development



The economic effects to be yielded by investigation, construction and operation (HLW+TRU) represent the estimated values in the prefecture with a municipality where the investigation is conducted.

(Source: Pamphlets and others of NUMO)

Current status of performance assessment in NUMO

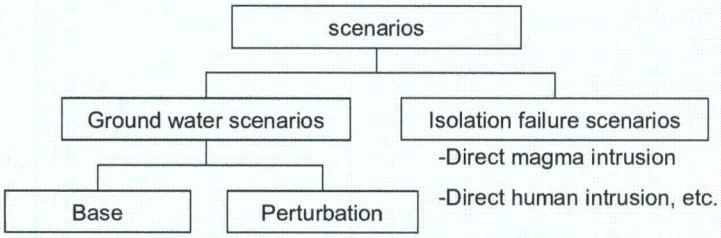
May. 28, 2010

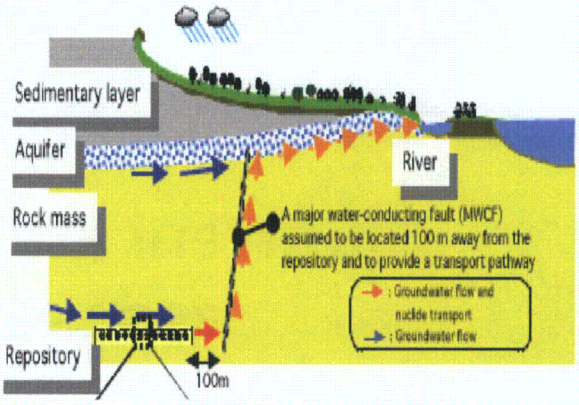
Takeshi Ebashi (NUMO)

Contents of this presentation

1. Safety Assessment in the H12 report
2. NUMO's approach for scenario development
   - 2-1. Storyboard
   - 2-2. Key concept of perturbed cases and highly unlikely cases
   - 2-3. Example of scenario development and assessment models

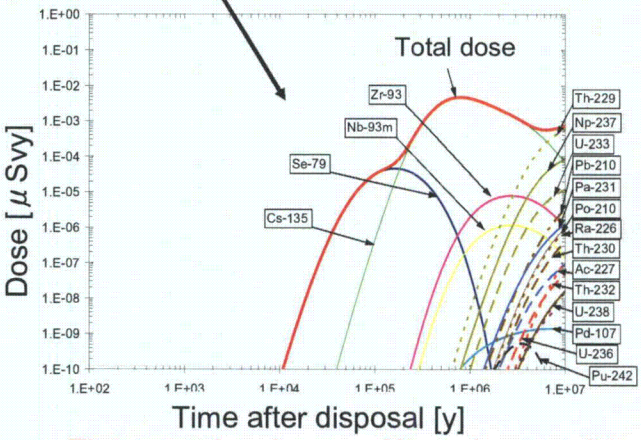
1. Safety assessment in H12 report (JNC, 2000)

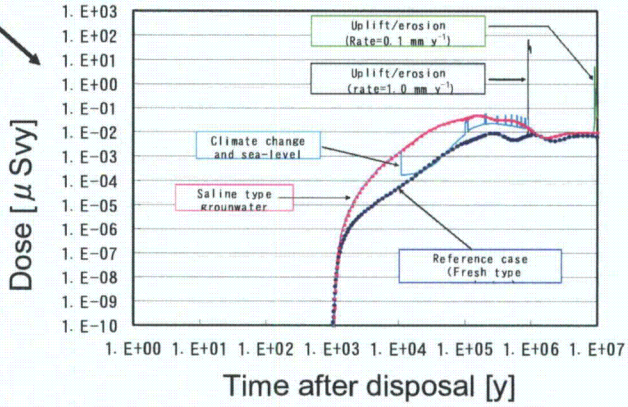




Assume initial natural conditions continue without significant change

Natural conditions alter due to uplift/erosion and climate change. Etc.

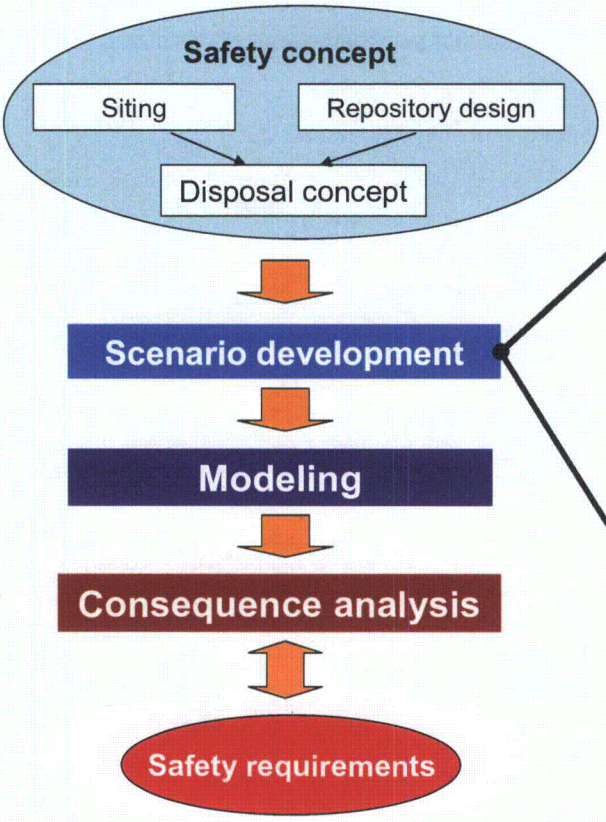




There are the change of boundary condition for performance assessment in Japan after H12 report (Especially, definition of scenario classification).

2. NUMO's approach for scenario development

Enhancement of scenario development methodology



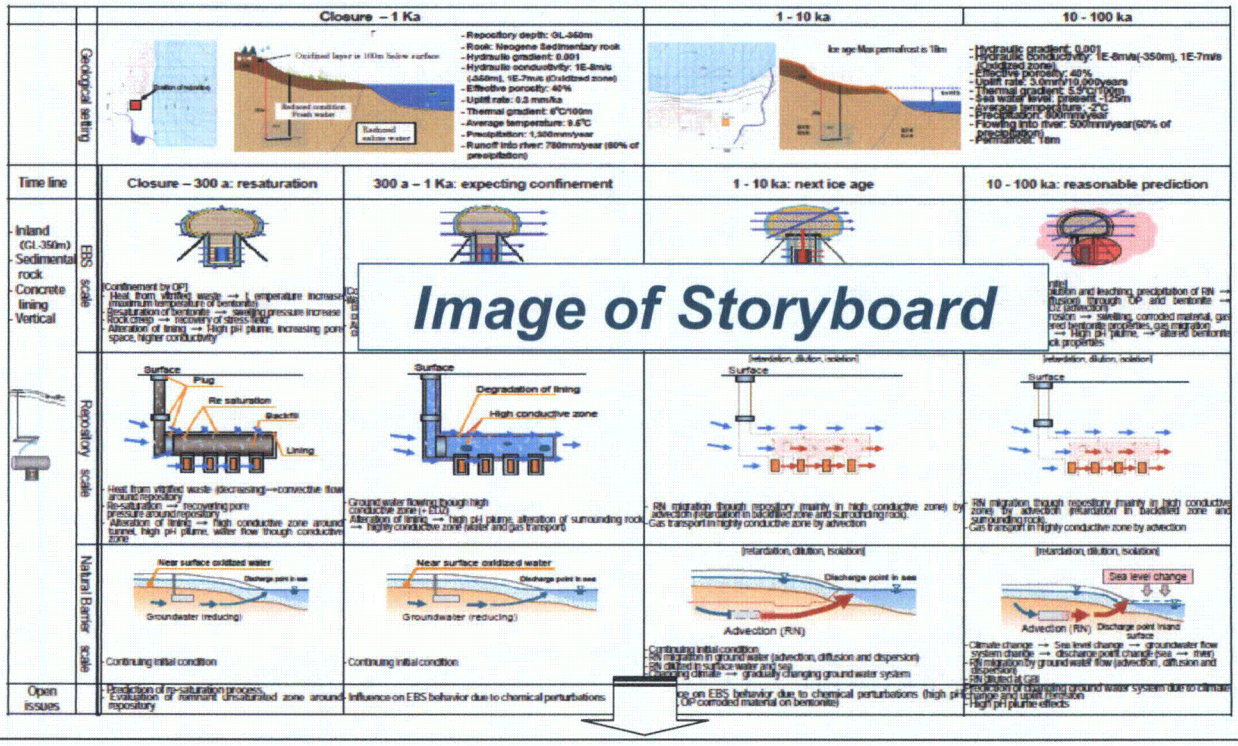
System understanding is executed based on a "Storyboard" integrating multidisciplinary (diverse) knowledge and argumentation between experts:

Based on system understanding and the safety function and the FEPs, scenario is specified.

- **-base (likely)**
- **-alternative (unlikely)**
- **-Highly unlikely**

2-1. Storyboard

- **The most likely (expected) processes are identified for each time frame and assessment scale on the basis of discussions between experts, for later definition of base case scenario.**
- **Open issues are also specified. Storyboard describes the most likely system evolution.**



Reflect scenario development based on the safety function and the FEPs

2-2. Key concept of perturbed cases and highly unlikely cases

Base assessment case : Most likely case derived from Storyboard (including uplift/erosion, climate change)

Perturbed cases A: Considering possible variation of parameters

Variations of base case

Perturbed cases B: Considering possible variations of conceptual models

- Change of RN migration process (e.g. gas)
- Change of GW flow path (e.g. hydrothermal, faulting)
- Change of geochemical condition (ditto)
- Change of water flux (ditto)

Alteration of base case

Highly unlikely cases:

1) Events only possible after about 100 ka

>100ka

Excluded by siting (e.g. east side of volcanic front)

Random occurrence (e.g. volcano) + subsequent influence

2) Events possible at any time, possibly several times

>100ka

Random occurrence (major fault movement, monogenic eruption + subsequent influence

3) Gradual phenomena

>100ka

Hydrothermal influence by magma activity (continuous)

Very unlikely but high consequence scenario :**Disruptive events**

1) Very unlikely distinct events (occurring only after 100ka)

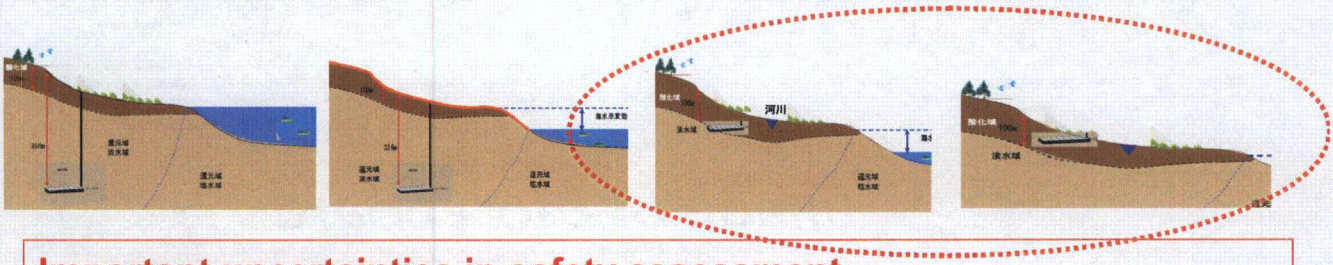
2) Very unlikely distinct events (occurring at any time)

3) Very unlikely continuous phenomena

2-3 Disruptive events in the safety assessment (1/3)

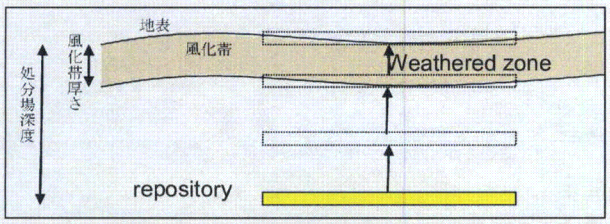
Scenario of exposure by uplift/erosion

Assume current rate of uplift and erosion continues beyond 100ka

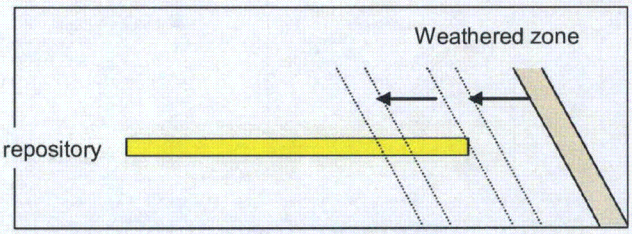


Important uncertainties in safety assessment:

- **Time of events: repository reaching the near surface weathered zone (oxidized ground water, higher conductivity)**
- **Modes of events: repository erosion geometry**



Pattern A (regional erosion)

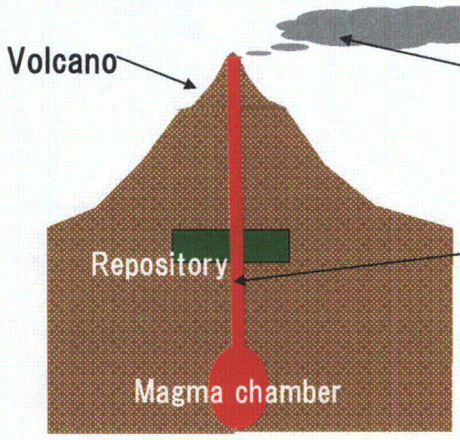


Pattern B (lateral erosion)

2-3. Disruptive events in the safety assessment (2/3)

Scenario of eruption through the repository

(prior geothermal impact would probably occur)



Important uncertainties in safety assessment

- **Volume of ash: dilution of waste expelled**
- **Scale of vent: number of waste packages directly impacted**

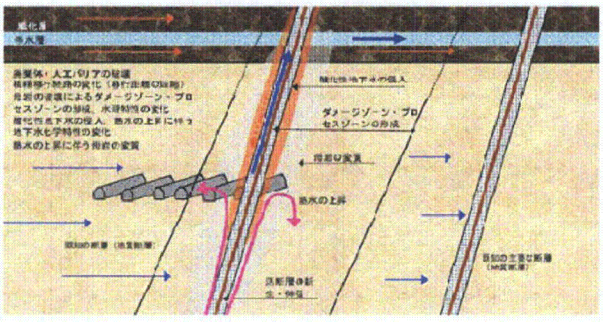
- Beyond 100ka, it was assumed that a new volcano could hit the repository once.
- In the preliminary assessment, frequency and probability of eruption were not discussed.
- Not yet specified scenario classification (site specific).

2-3. Disruptive events in the safety assessment (3/3)

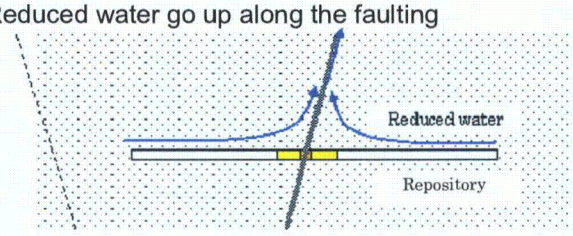
Scenario of faulting through the repository

Important uncertainties in the safety assessment

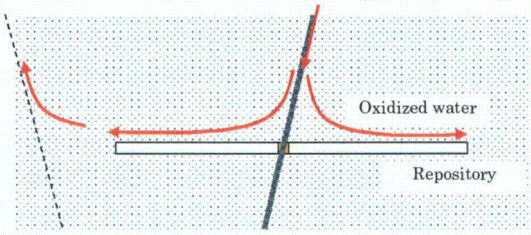
- **Mode of a fault hit the repository**
- **Scale of disturbed zone along to a new fault**
- **Modes of surrounding ground water flow change (direction, chemistry, flux)**



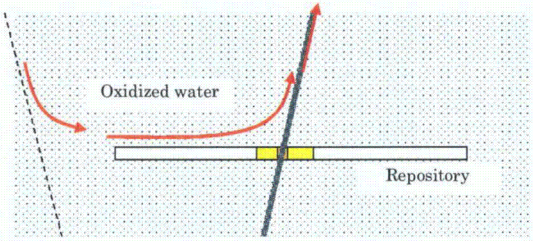
a) Reduced water go up along the faulting



b) Oxidized water comes down along the faulting & repository



c) Oxidized water from other faulting



Thank you for your attention

J N F L

Regulation for Reprocessing Facilities in Japan

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Contents

1. Executive summary 1
2. Purpose of the document 1
3. Nuclear Safety 1
   3.1. Objectives 1
   3.2. Safety Evaluation 1
   3.3. Quality system 5
4. Licensing 5
   4.1. Principle 5
   4.2. Organization 5
   4.3. Law 7
   4.4. Regulation Flow 7
      4.4.1. Design Stage 8
      4.4.2. Construction Stage 10
      4.4.3. Pre-operation Stage 10
      4.4.4. Operation Stage 10
5. Application for license 10
   5.1. Application of designation for reprocessing business 10
   5.2. Application of sanction for design and method of construction 11
6. Test operation 12
7. Modification 13
8. Periodical Safety Review 13
9. Decommissioning 13
10. Recommendation 13
11. Reference 13

1. Executive summary

2. Purpose of the document

The purpose of this document is to describe the outline of Japanese nuclear regulation system especially nuclear safety methodology.

3. Nuclear Safety

3.1. Objectives

Refer IAEA Safety Standards "fundamental Safety Principles" No.SF-1

The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation.

To ensure that facilities are operated and activities conducted so as to achieve the highest standards of safety that can reasonably be achieved, measures have to be taken:

(a) To control the radiation exposure of people and the release of radioactive material to the environment;

(b) To restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation;

(c) To mitigate the consequences of such events if they were to occur.

3.2. Safety Evaluation

The purpose of safety evaluation is that the defense-in-depth concept is properly adopted in the fundamental design philosophy of the plant and that the isolation of the plant from the general public is adequately established in assessing the safety of the reprocessing plant.

(1) Evaluation for the validity of safety designs

In order to evaluate the validity of safety designs, Design Basis Events are selected and evaluated to confirm that the defense-in-depth concept is properly adopted in the fundamental design philosophy of the reprocessing facilities.

The Design Basis Events mean those events which should be taken into account in the design and evaluation of the reprocessing plant and selected from among many incidents possible to introduce abnormal state of the reprocessing facilities.

The Design Basis Events are selected by deterministic method.

The Design Basis Events are categorized "Anticipated Transients (AT)" that are the events to confirm suitability of preventive measures against escalation of transients and "Beyond Anticipated Transients (BAT)" that are the events to confirm suitability of mitigative measures against consequences from accidents.

Anticipated Transients are the events that will disturb the reprocessing facilities conditions beyond normal operating limits as a result of a single failure or malfunction of equipment or a single operator misoperation anticipated during the life time of the reprocessing plant and those events that occur with similar frequencies as the above and may cause the unplanned reprocessing facilities operating conditions.

Beyond Anticipated Transients are the events that should be postulated from the standpoint of assessment of the propriety of safety design of the reprocessing facilities because of the possible release of radioactive materials in excess of the annual release of radioactive materials established for the evaluation of dose equivalent in normal operation, although smaller probability of occurrences.

(2) Site Evaluation Accidents

In order to evaluate the validity of the isolation distance between the reprocessing facilities and the general public, the Site Evaluation accidents are selected by assuming a release of radioactive materials in excess of design basis event from technological point of view although the possibility of such release is much smaller than that of design basis event.

This evaluation is performed by the deterministic method same as the Design Basis Event evaluation.

(3) Safety Evaluation of Rokkasho Reprocessing Plant

The safety evaluation in RRP at the basic design stage, the Design Basis Events are selected by HAZOP(Hazard and Operability Study) method.

(a) Anticipated Transients (AT)

Before selecting the Anticipated Transient, 400 events were studied. In these events, 40 events were selected as Anticipated Transients. 40 events were categorized according to the kind of risk and selected severe 7 events.

- Abnormal rise in organic solvent temperature in back-extraction column of plutonium purification process
- Abnormal rise in steam temperature in highly active liquid waste concentrator
- Abnormal rise in hydrogen concentration of reduction gas of uranium-plutonium mixture denitration process
- Abnormal rise in plutonium concentration of plutonium barrier of partition process
- Abnormal increase in steam concentration of off-gas due to decrease in cooling capability of condenser of highly active liquid waste concentrator
- Temperature rise in reducing furnace of uranium-plutonium mixture

denitration process

- Loss of off-site electric power

(b) Beyond Anticipated Transients (BAT)

Before selecting the Beyond Anticipated Transients, 600 events were studied. In these events, 23 events were selected as Anticipated Transients. 23 events were categorized according to the kind of risk and selected severe 7 events.

- Organic solvent fire in a cell of plutonium purification process
- Abrupt decomposition of TBP complex in plutonium concentrator
- Criticality in dissolver
- Leakage of highly active liquid waste from the piping of highly active liquid waste storage facility
- Leakage of melted glass from vitrification facility of highly active liquid waste
- Drop of spent fuel assembly at spent fuel reception and storage facility
- Loss of total electric power for a short time

(c) Site Evaluation accidents

The Site Evaluation accidents are selected by assuming a release of radioactive materials in excess of following two severe BAT events from technological point of view although the possibility of such release is much smaller than that of design basis event.

- Criticality in dissolver
- Organic solvent fire in a cell of plutonium purification process

(d) Situation of the development of risk analysis methodology

In Japan, a study regarding regulations utilizing the risk information, as undertaken by nuclear power plants in Europe and in U.S. is taken up positively.

Following such a flow, JNFL is also implementing risk evaluation in accordance with the importance, with an aim to realize in future, a rational operation management by utilizing risk information. For important incidents with big impact at the time of occurrence (Hydrogen explosion incident in Pu concentrated solution storage vessel, boiling incident of high active concentrated effluent), risk evaluation utilizing the PSA method adopted in nuclear reactors is implemented.

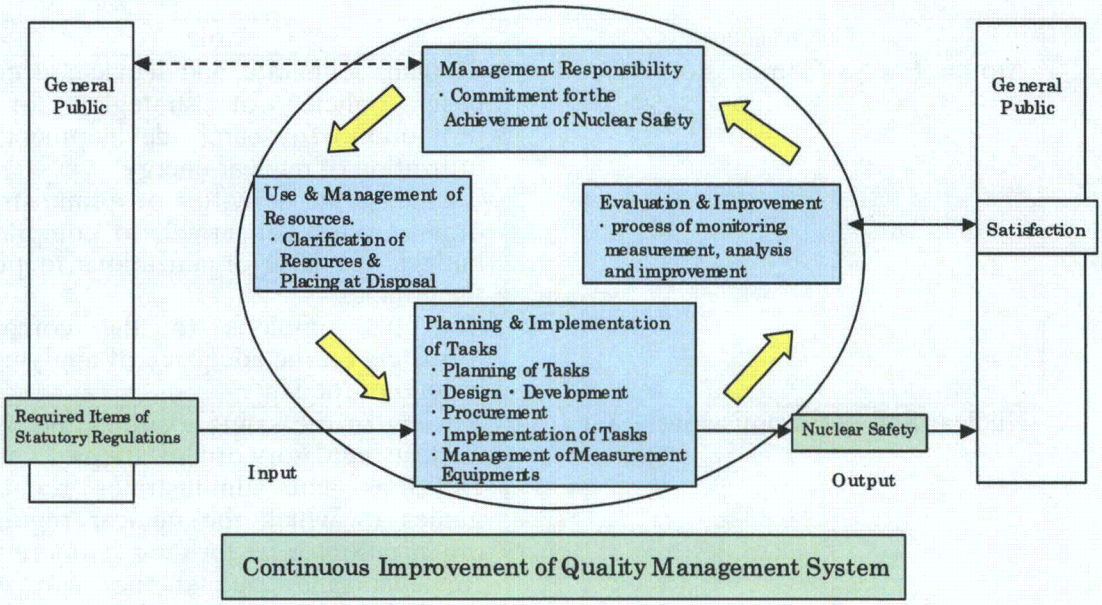
On the other hand, since diverse types of incidents are anticipated in a reprocessing plant, a simplified PSA method has been developed in order to implement risk

evaluation for such risks. By using this method, evaluation of risk of all the incidents extracted by HAZOP method (including the above referred important incidents) and evaluation of the risk importance of the related equipment and functions are implemented.

Also, regarding seism which is an external incident, the importance of seismic resistance is defined in accordance with the deterministic method, then the design best coping with the importance is implemented, and at the same time, due to the request by the regulatory authorities in 2006 to take up quantitative evaluation of the seismic risks, JNFL is making efforts to establish the probabilistic safety evaluation method.

3.3. Quality system

2 A Model of Quality Management System For Maintaining Safety In Nuclear Facilities



4. Licensing

4.1. Principle

The purposes of the regulation by the law are to ensure that the uses of nuclear source material, nuclear fuel material and reactors are limited to peaceful purposes and carried out in a planning manner, and the same time, to ensure the public safety by preventing the hazards due to these materials and reactors and protecting nuclear fuel material.

4.2. Organization

The body to regulate is divided some ministries according to the following facility.

Ministry	Regulating Facility
Ministry of Economy, Trade and Industry (METI)	Power Reactor, Fuel Cycle Facilities
Ministry of Education, Culture, Sports, Science and Technology (MEXT)	Research Reactor, Test Reactor, Radio Isotope Facility
Ministry of Land, Infrastructure, Transport and Tourism (MLIT)	Transportation of Nuclear Fuel Material and Radio Isotope

Under Ministry of Economy, Trade and Industry(METI), Agency for Natural Resources and Energy has the role to regulate the nuclear power and cycle facilities.

Furthermore, the following independent commissions exist under Cabinet Office.

Commission	Role
Atomic Energy Commission(AEC)	-To plan, deliberate, and decide concerning basic policies or strategies for the promotion of research, development, and utilization of nuclear energy -To adjust the activities of administrative organizations concerned, to compile the budget for these organizations to pursue the policies -To give opinions to the competent Ministers on the adequacy of applying the criteria of the law
Nuclear Safety Commission(NSC)	-Review of the safety examination by the nuclear regulatory organizations -Develops and administrates regulatory guides to which the nuclear regulatory organizations refer for their safety review -Reviews and audits the subsequent regulation by the nuclear regulatory organizations

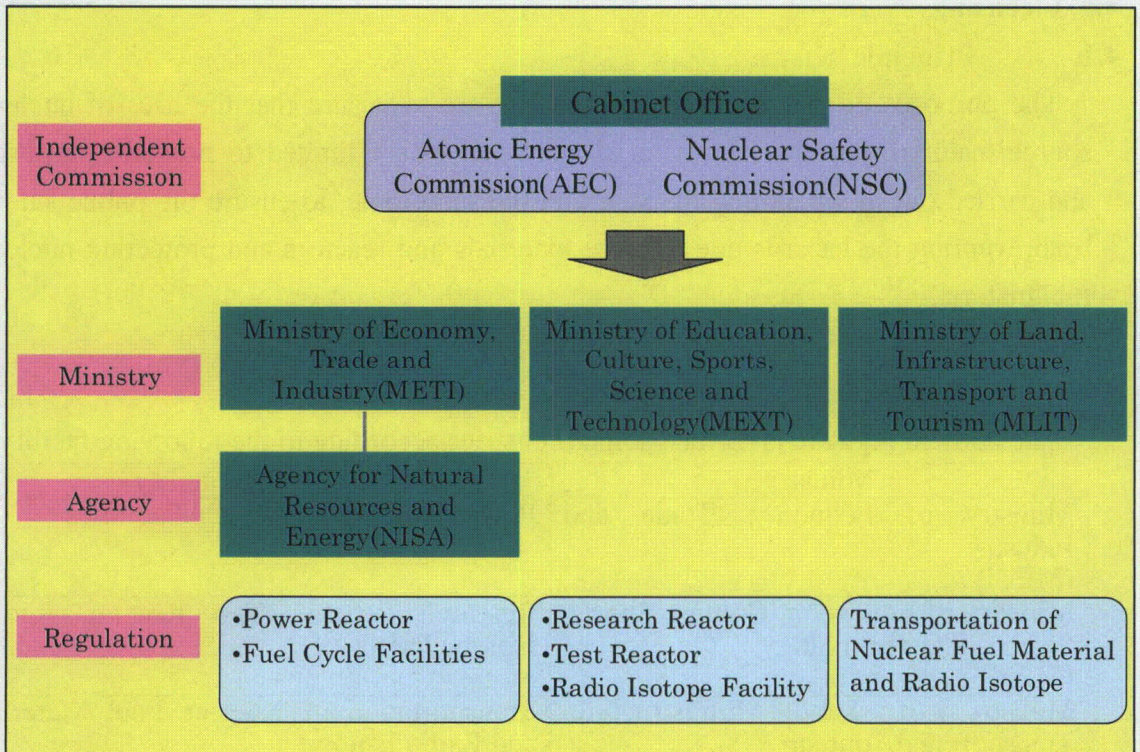


Fig. Nuclear Regulation Organization in Japan

4.3. Law

Nuclear regulation low shows the following.

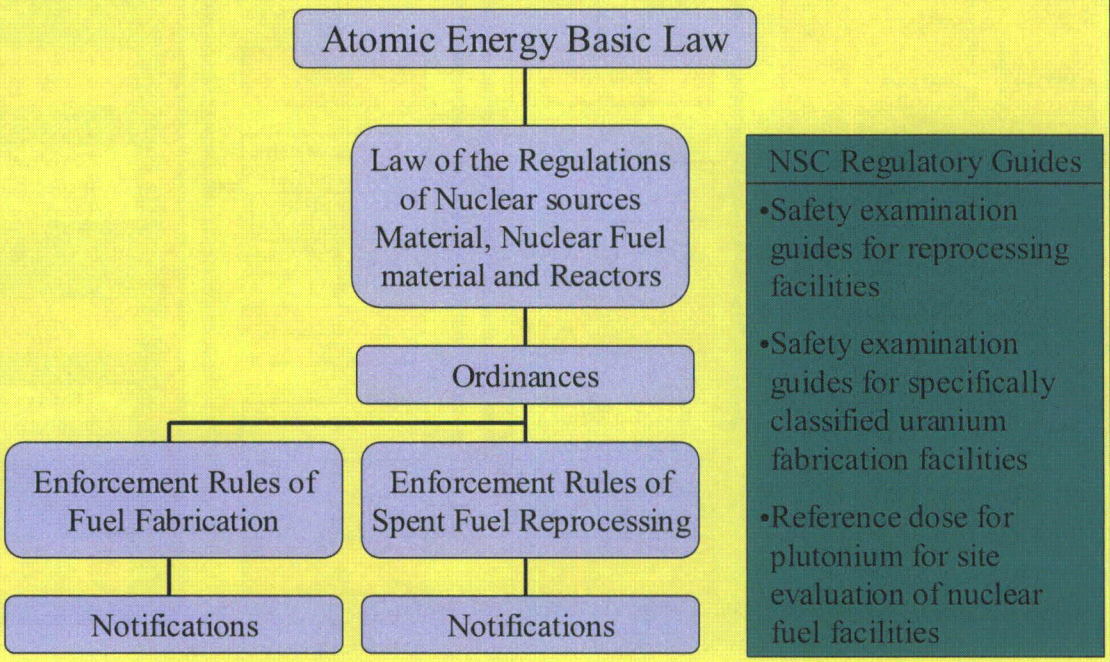


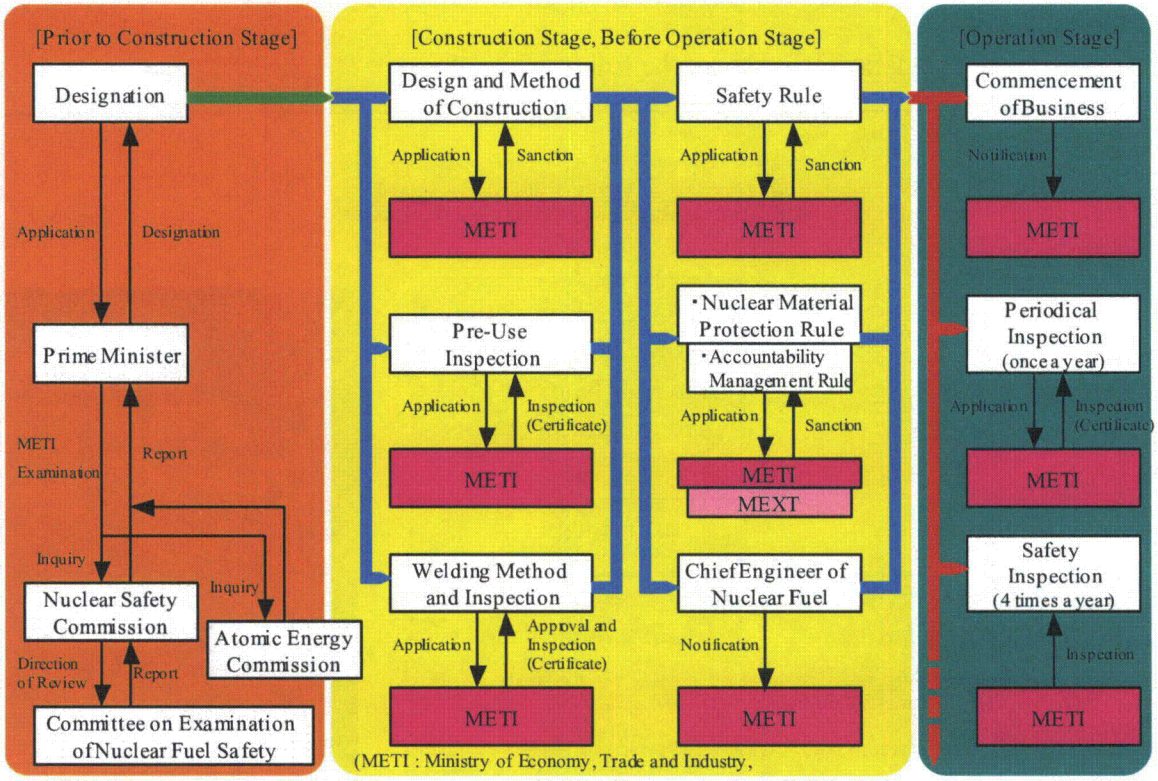
Fig. Nuclear Regulation Law in Japan

4.4. Regulation Flow

Nuclear regulation in Japan is the multi step check system in each stage that is design, construction, operation and decommissioning. The characteristic of reprocessing plant regulation for the safety point of view, is as follows.

- Large amount of activities
- Criticality Safety
- Several chemical processes and mechanical processes
- Many type of nuclide as fission products and trans uranium nuclides
- High active waste and TRU waste

Safety Regulation Scheme on Reprocessing Facilities



MEXT: Ministry of Education, Culture, Sports, Science and Technology)

4.4.1. Design Stage

Licensee makes the application of designation for reprocessing business and submits to the Prime Minister. The first stage examination of the application is performed by NISA. After the examination and concerned the public hearing, the second stage examination is performed by AEC and NSC. During this examination, Committee on Examination of Nuclear Safety advices to NSC as nuclear safety point of view. After the examination is finished to complete, AEC and NSC report that the application is conformed the criteria for designation, the Prime Minster makes the designation.

The criteria for designation are as follows.

- The reprocessing facilities are not likely to be used for purposes other than peace.
- Authorization is not likely to turn out to impede the planned promotion of the development and utilization of nuclear power.
- There are the technical ability and the financial position needed to carry on the business property.
- The location, structure and equipment of the reprocessing facilities do not interfere with the prevention of accidents that may be caused by spent fuel, material separated from spent fuel, or material contaminated them.

The examination is performed according to NSC regulatory guide "Safety

examination guides for reprocessing facilities" and "Reference dose for plutonium for site evaluation of nuclear fuel facilities".

In the safety analysis of a "reprocessing facility", the focal point of its confirmation is to confirm whether an appropriate location selection or a safety design is implemented so that the safety of the general public is secured in case of not only at the time of normal operation but even in the worst case of an assumed accident. Focal points of examination are as follows:

- That the safety design is made in such a way so as not to endanger the safety of the reprocessing facility due to its location point, its surrounding natural phenomena (seism, meteorology, water resources) and social phenomena (such as transportation).
- That regarding containment of radiation within the facility, all possible measures such as adoption of cell structure are taken, and at the same time, radiation protection and control are undertaken so that the employees' exposure limit will not be exceeded.
- That it should be a safety design in which scrupulous measures are taken especially for "criticality control" and "fire・explosion prevention" by chemical material. That the design is also made so as not to damage the integrity of the principal installations and facility even in case of equipment breakdown or erroneous operation.
- That in operation of the facility, it is a safety design able to prevent the occurrence of abnormality, promptly discover its occurrence , and prevent its expansion (note: this corresponds to the notion of "defense in depth").
- That even assuming an evaluated location accident (equivalent of a grave accident at nuclear reactor facility and an assumed accident), the condition of location is such that the separating distance between the facility concerned and the general public is properly assessed so that the safety of the public is assured (not causing excessive exposure to the public).

Taking into account the basic policy toward safety design as above, the regulatory authorities, when conducting a concrete safety examination of the reprocessing facility, are to judge on the basis of the "Application for the Designation of Reprocessing Business" presented by JNFL, the adaptability with the two guidelines, namely " Regarding the approximate dose level for Plutonium required for the evaluation of the location of a nuclear fuel facility" and "The guide line for the safety examination of a reprocessing facility " as well the criteria defined by law. In case of necessity, local

surveys and analytical calculations are carried out in parallel, to use them as the basic data for the examination.

4.4.2. Construction Stage

Licensee makes the application of design and construction method and submits to the President of METI. The examination of the application is performed by NISA. The application is conformed the following criteria, the President of METI approves the sanction of design and construction method. Normally, the application is divided several parts according to the progress of the construction for the reprocessing facilities.

- The design and method of construction have been given designation.
- The design and method of construction are in compliance with the technical standard.

4.4.3. Pre-operation Stage

Before start up the operation, licensee has to be approved the safety rule and nuclear material protection rule from the President of METI and the accountability management rule from the President of MEXT.

4.4.4. Operation Stage

During operation of the reprocessing plant, licensee has to be checked periodically the function of the facility or equipment by NISA inspector once a year. And also, licensee has to be checked periodically the situation to respecting the safety rule four times a year.

5. Application for license

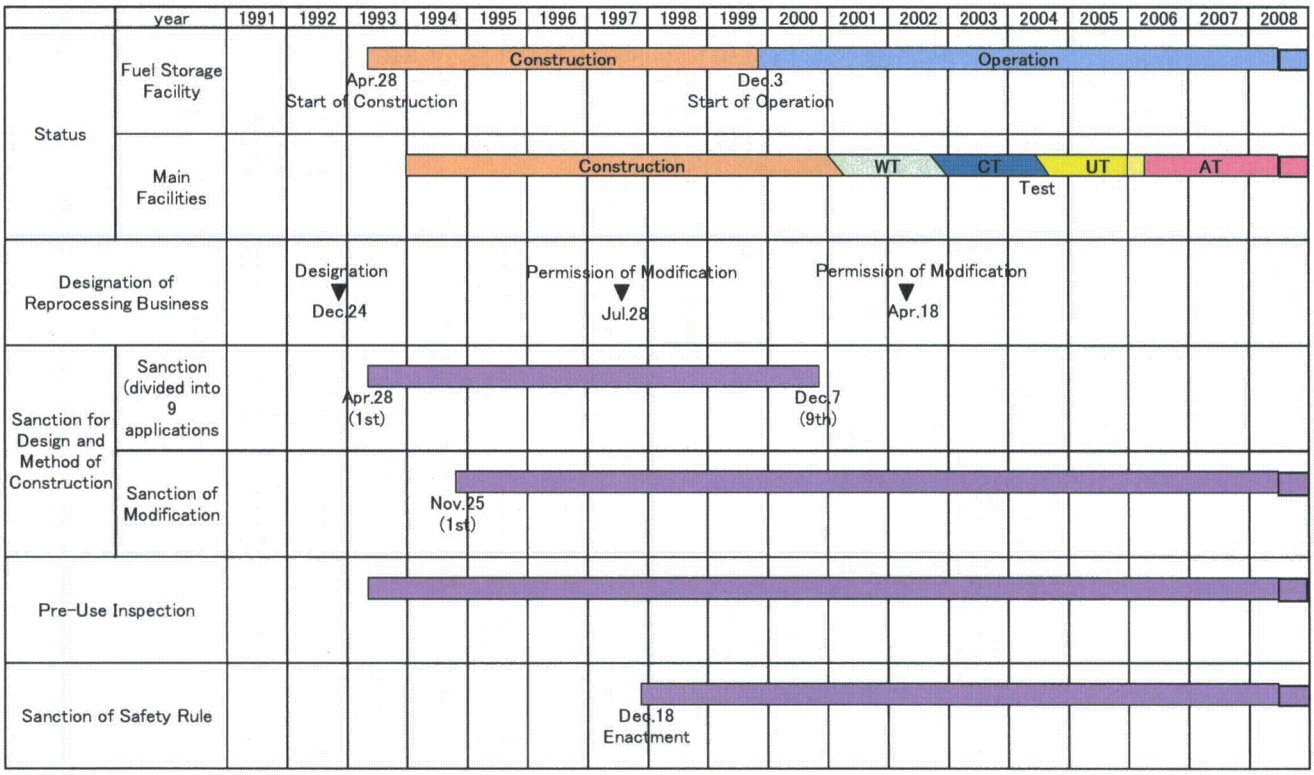
5.1. Application of designation for reprocessing business

- Submit to the Prime Minister : 1989/03/30
- Designation of the reprocessing business : 1992/12/24
  Three times modification of the application until now
- JNFL makes several publication documents in order to explain the detail of the specific topics in the application. It shows the example as follows.
  -Criticality safety design for each facility
  -Activity evaluation for atmosphere and see release
  -Safety Evaluation by HAZOP method

5.2. Application of sanction for design and method of construction

- Divided nine parts
- First Submit to the President of METI : 1993/01/13
- Sanction of first application : 1993/04/14
- Second application submit : 1993/07/30
- Sanction of second application : 1993/12/27
- Sanction of last(ninth) application : 1999/12/07

  Thirty-three times modification of the application until now



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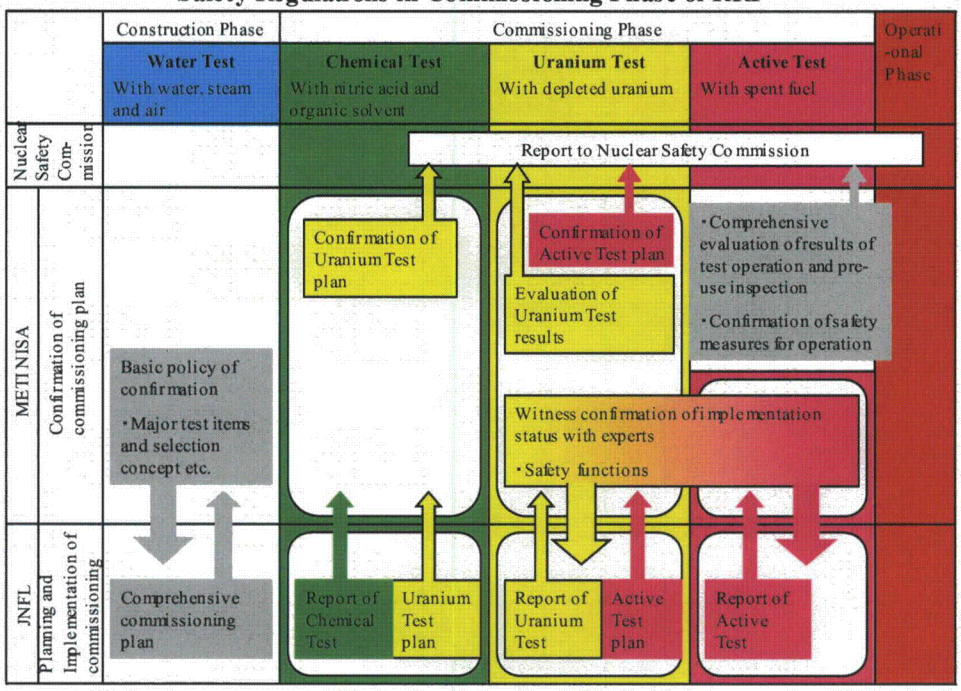
6. Test operation

Test operation is divided 5 steps that are water test, chemical test, uranium test and active test. The water test stage is very close to the construction stage, because the test is performed with temporary means. During water test, NISA made the basic policy confirmation in test operation phase according to the comment of NSC at the time in the designation of reprocessing business. According to the policy, JNFL made the comprehensive commissioning plat and report to NISA. After water test, for each step, JNFL made the test plan and report to NISA. NISA checked these and performed the witness confirmation. NISA also reported to NSC the result of the tests.

Safety Regulations in Commissioning Phase of RRP



(a) General Plan of Test Operation

Contents include the following:

- Purpose of Test Operation and its schedule, principal test items of each step and rationale for their selection
- Organization and responsibility relative to Test Operation
- Conditions for decision for the completion of Test Operation, and for moving to the next step of test (for each of Chemical Test, Uranium Test and Active Test respectively)
- Safety measures during Test Operation
- Test Operation procedures and report
- Method and procedures for examination and verification of the Test Operation Plan and the Test Operation Report

- Treatment of non-conformity
- Education and training
- Record management

(b) Uranium Test Plan and Test Operation Plan

- Purpose and contents of each test selected in (a) above.
- Safety measures for each Test Operation (criticality, fire and explosion, erroneous operation of installations and equipment, accident of installations and equipment, measures for the handling of chemicals, management of temporary structures, obligations to be respected by operators relative to operation, etc.)
- Conditions and limits relative to test operation (nuclear, chemical, thermal, etc.)
- Radiation control during test operation
- Disposal of waste material (treatment, storage and disposal, etc.)

7. Modification

The regulation in Japan, the modification of each application has to be examined by NISA.

8. Periodical Safety Review

Periodical Safety Review(PSR) is performed every 10 years. In the application of PSR, the situation of safety implementation and the reflection of newest technological knowledge has to be evaluated.

9. Decommissioning

JNFL don't have the experience the decommissioning of reprocessing facilities.

10. Recommendation

The regulation for reprocessing facilities are composed from many different regulations and makes it effective during long time on each step of the facilities, from designing to decommissioning mentioned above. Therefore, one of the most important requirements for theses regulations is the balance in many other regulations of its country.

11. Reference

[1] IAEA Safety Standards "fundamental Safety Principles" No.SF-1