Types and generation of waste

Waste management and public cleansing law

廃掃法（廃棄物の処理 および清掃に関する法律） http://www.env.go.jp/en/lar/wastelaw

Wastes: refuse, bulky refuse, ashes, sludge, excreta, waste oil, waste acid and alkali,carcasses and other filthy and unnecessary matter, which are in solid or liquid state (excluding ***radioactive waste*** **and waste polluted by radioactivity*, soils generated in construction**).

Wastes
- （一般廃棄物）**Municipal waste (household, office paper)**:
- （産業廃棄物）**Industrial waste: results as business activities**

*Agency for Natural Resources and Energy http://www.enecho.meti.go.jp/
Ministry of Economy, Trade and Industry

incombustible（5 stable wastes）

Disposal of Radioactive Waste

Type of radioactive waste:

- **Waste from commercial nuclear power generation:**
- **Waste from military purposes (vessels, weapons)**
- **Waste from research, industrial and medical uses**

+

Wastes contaminated by radionuclide from the accident of the nuclear power plant

Waste from commercial nuclear power generation

- ***Spent nuclear fuels =>reprocessing***

=> ***nuclear fuel*** *(Uranium oxide, uranium & plutonium oxide (MOX)*
high level radioactive waste ***(liquid & solid)***

solidified with glass
(vitrified :ガラス化)

temporarily stored in canister in 30-50 years for cooling

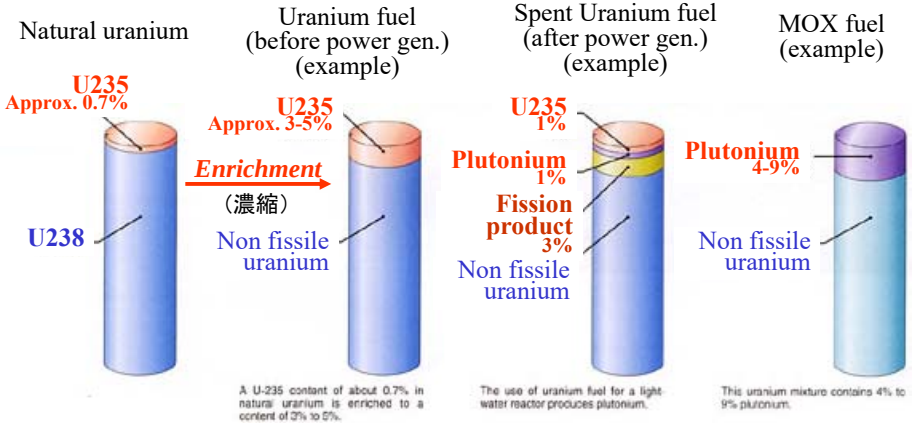
final disposal in geologic formation

- ***Operation and maintenance of NPP***

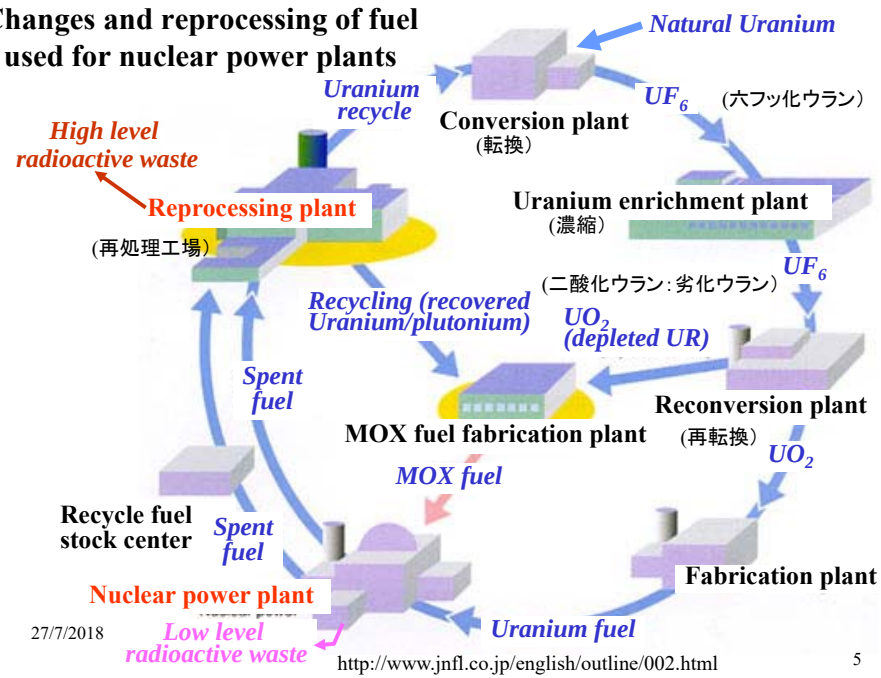
=> ***low level radioactive waste***

(work clothes, gloves, and water and paper used to clean the power station floors)

Fraction of Radionuclides in Nuclear Fuels



Changes and reprocessing of fuel used for nuclear power plants

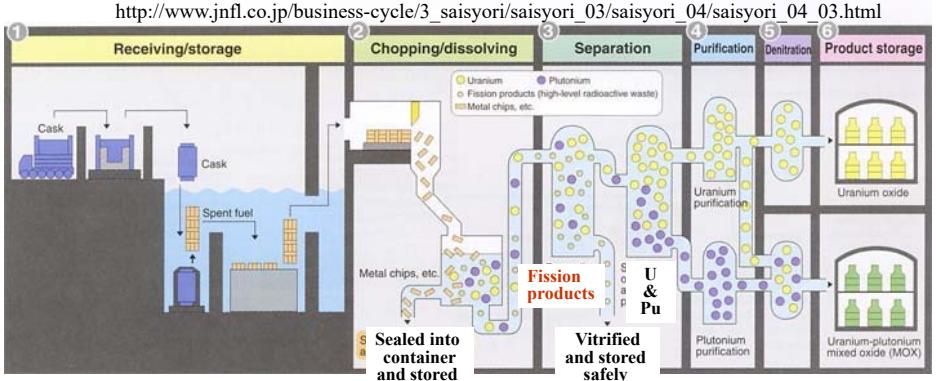


http://www.jnfl.co.jp/english/outline/002.html

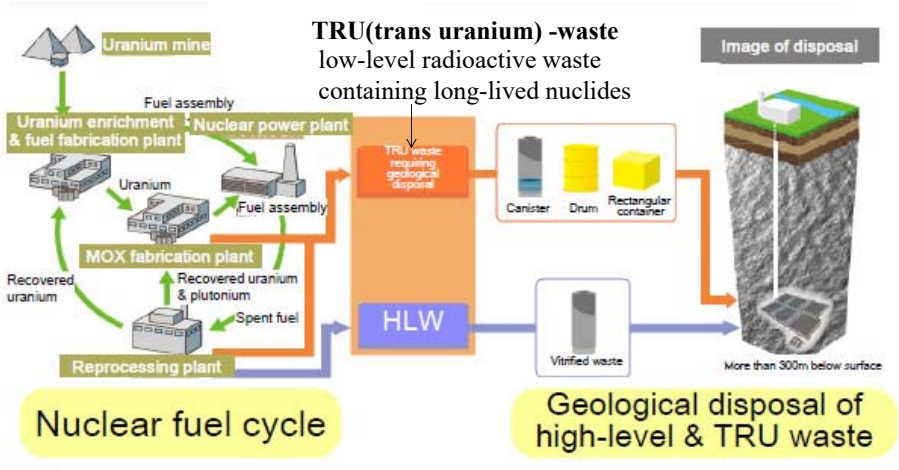
Reprocessing flow

http://www.jnfl.co.jp/english/outline/002.html (NA)

http://www.jnfl.co.jp/business-cycle/3_saisyori/saisyori_03/saisyori_04/saisyori_04_03.html

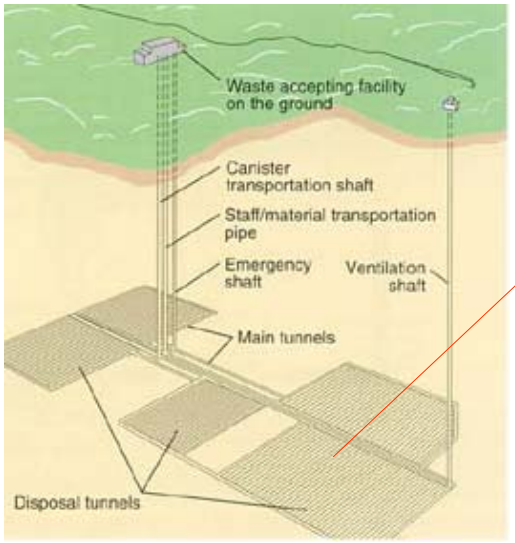


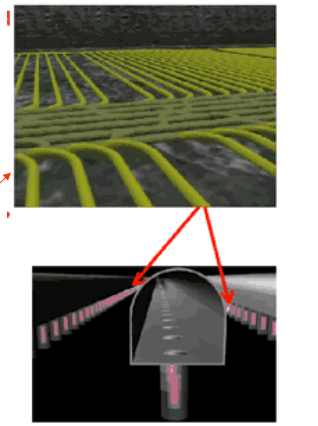
Radioactive waste for geological disposal



TRU(trans uranium) -waste
low-level radioactive waste containing long-lived nuclides

Image of final disposal in geologic formation

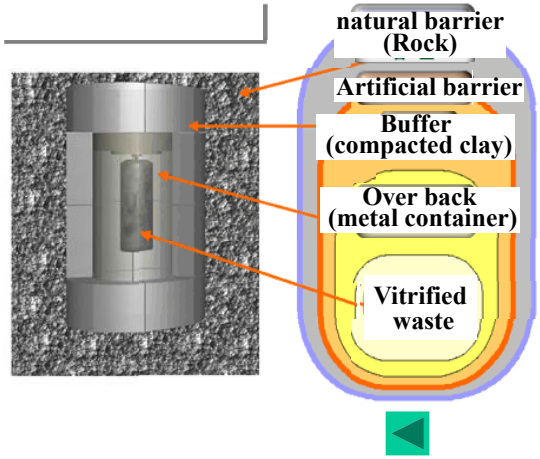




http://www.numo.or.jp/denshi/top-a.html

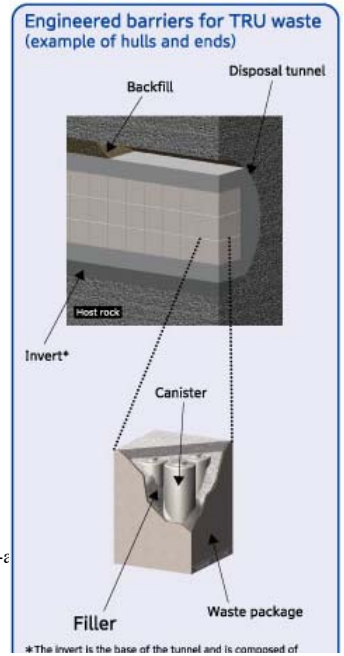
http://www.jnfl.co.jp/english/outline/004.html

Multi-barrier of HLRAW



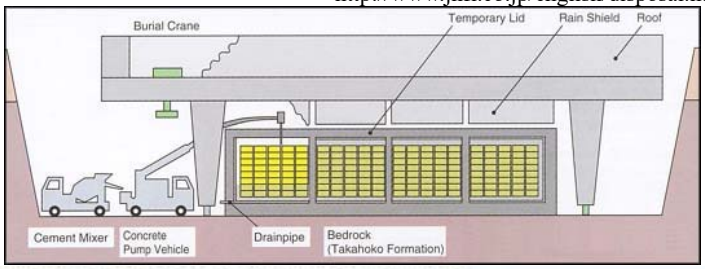
http://www.numo.or.jp/denshi/top-a

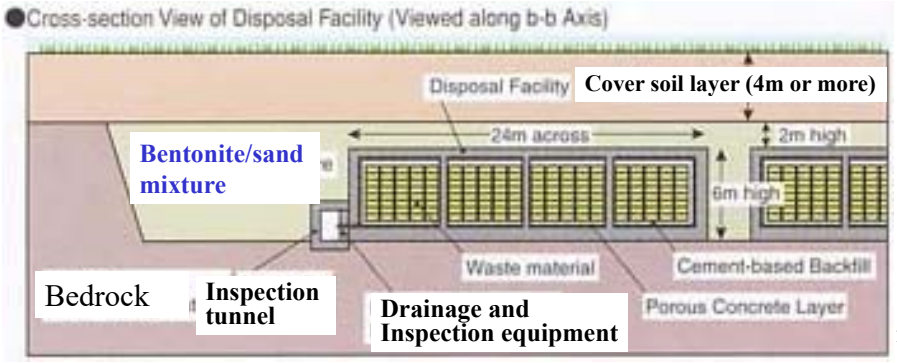
TRU waste



Disposal of Low Level Radioactive Waste

http://www.jnfl.co.jp/english/disposal.html

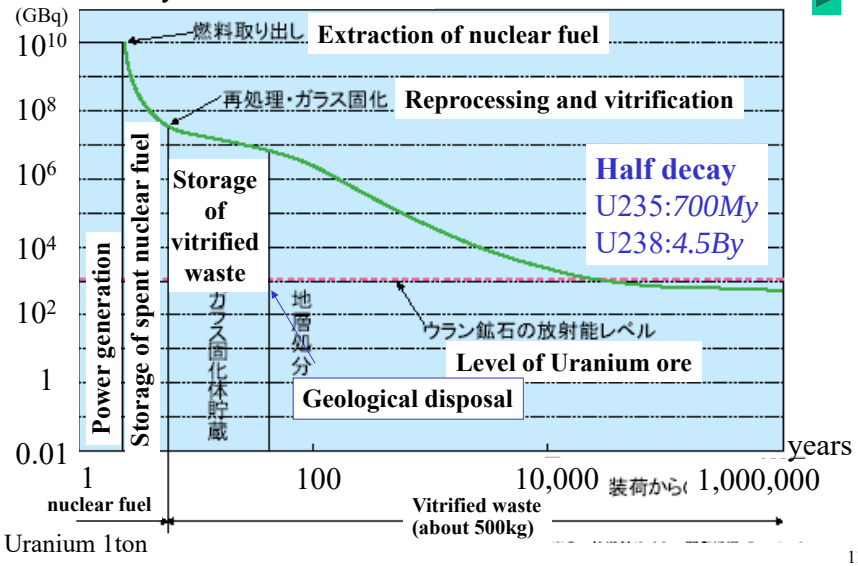




Decay of HLRAW

Radioactivity in 1ton nuclear fuel

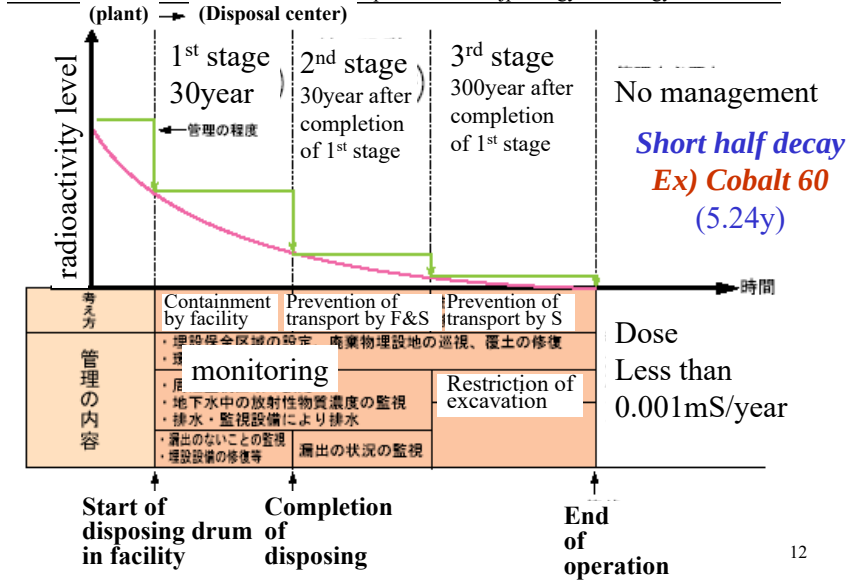
other radionuclides



http://www.iae.or.jp/energyinfo/energydata/data3044.html

Staged management of low level radioactive waste

http://www.iae.or.jp/energyinfo/energydata/data3043.html



Wastes of radioisotopes for research, industrial and medical uses

Collected RI waste in terms 200L drum

type \ year	1998	1999	2000	2001	2002
Total	16,709	15,735	18,455	16,133	16,636
Solid					
flammable	1,467	1,331	1,330	1,295	1,364
less-flammable*	8,179	7,477	7,791	7,355	7,610
inflammable	1,645	1,505	1,532	1,520	1,628
dry animal	246	222	200	202	234
Liquid	318	309	312	307	356
Filter	4,328	4,382	4,083	4,456	4,552
Incompressible solid	526	509	3,207	998	892

Treated RI waste in terms 200L drum

type \ year	1998	1999	2000	2001	2002
Total	10,389	14,475	10,366	11,361	9,057
Solid					
flammable	581	672	251	492	173
less-flammable*	4,890	6,380	5,008	5,567	4,989
inflammable	3,255	2,297	1,954	1,413	1,235
dry animal	75	25	–	–	100
Liquid					
organic	–	–	94	45	127
inorganic	18	–	–	–	–
Filter	1,570	5,079	2,116	3,844	2,403
Incompressible solid	–	22	943	–	30

Medical RI waste

⇩

Japan Radioisotope Association

Non-medical RI waste

⇩

Atomic energy Research Insititute

⇨ Current treatment ***Storage in drum***

http://www.jrias.or.jp/jrias/handlers/getfile.cfm/4,331,107,132,html

Current treatment of RI Waste: ***Storage of the waste in drum not final disposal***

http://www.jrias.or.jp/jrias/index.cfm/4,533,97,32,html

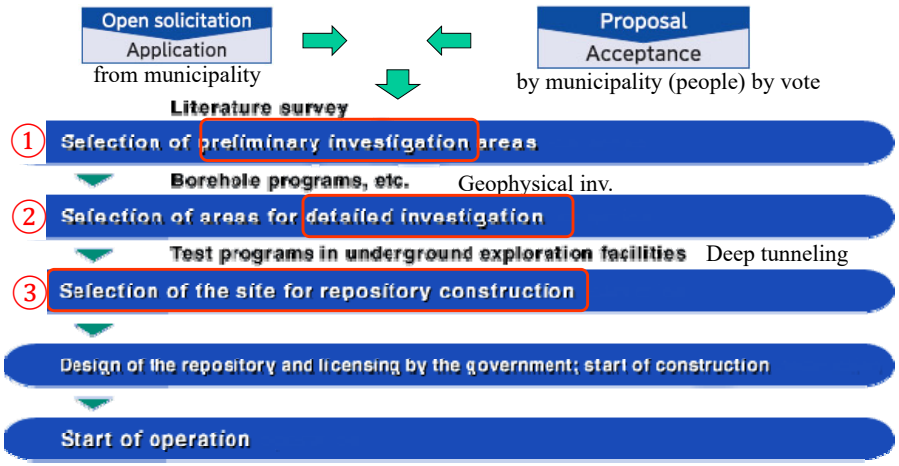
Process of Final Disposal

NUMO 原子力発電環境整備機構

Nuclear Waste Management Organization of Japan

http://www.numo.or.jp/en/jigyou/new_eng_tab03.html

http://www.numo.or.jp/en/publications/pdf/GDALC_20121114.pdf



http://www.numo.or.jp/en/jigyou/new_eng_tab04.html

Time table of HLRAW Repository

NUMO Report Evaluating Site Suitability for a HLW Repository (2004)

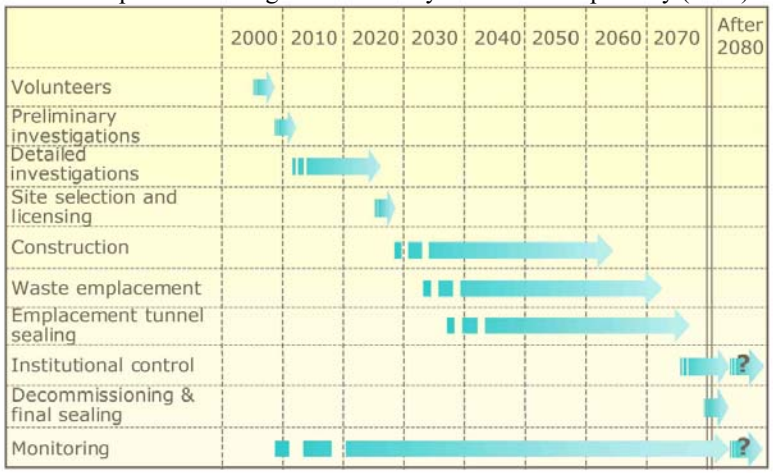


Figure 1-3: The staged repository development programme and possible milestones. The time plan after site selection has a model nature as it will depend, to some extent, on the repository concept selected.

Plan of HLRAW in the world

waste type / rock type / depth / current conditions / plan

	廃棄物形態	岩種	処分深度	現状	計画
アメリカ US	使用済燃料 ガラス固化体	凝灰岩	約350m	1991年：ユッカマウンテンでサイト特性調査開始 1998年：サイト実現性評価報告書公表 **cancelled** 2002年：米議会が最終処分場としてユッカマウンテンを承認	2004年：DOEがNRCへ建設許認可申請 2005年：DOEが処分場建設に着手 2010年：処分場操業開始
フランス France	使用済燃料 ガラス固化体	花崗岩 粘土層	400～1000m	1995年：地下研究施設候補地３ヶ所選定 1996年：候補地での地下研究所建設許可申請並びに公聴会 1998年：粘土層の地下研究施設建設サイト決定 1999年：粘土層の地下研究施設建設許可 2000年：花崗岩地下研究施設サイトの選定を開始したが、反対運動により中断 => New site (mud rock)	2006年：国家評価委員会、深地層処分、分離変換技術、長期貯蔵の３分野の研究開発に関する総合評価報告書を評価し、処分方針決定
ドイツ Germany	使用済燃料 ガラス固化体	岩塩層	660～900m	1977年：ゴアレーベンを候補サイトとして選定 1984年：処分に関する安全研究報告書(PSE) 1988年：性能評価書(GEC-PAGIS) 1997年：立坑掘削終了 Terminated	2000年：政府-電力の協定によりサイト特性調査は３～10年中断 2002年：処分場サイト委員会による検討終了 2030年：操業開始予定
ベルギー	使用済燃料（返還廃棄物）	粘土層	220m	1974～89年：モル地下研究所での処分の安全性評価研究 1989年：安全評価書(SAFIR-I) 1994年：深地層処分研究プログラム策定開始	2000～2015年：実廃棄物実証試験 2025年：王命で処分場の許認可取得 2035年：処分場操業開始
フィンランド Finland	使用済燃料	花崗岩	約500m	1983年：調査活動開始 **Decided, Onkalo** 1987年：５ヶ所の調査区域選定 1995年：環境影響評価報告書提出 2001年：処分場予定地決定（国会承認）	2003～2004年：地下調査施設建設開始 2006年：処分場深度での調査 2010年：処分場建設着工 2020年：処分場操業開始
スウェーデン Sweden	使用済燃料	花崗岩	約500m	1983年：概念設計、評価報告書(KBS-3) 1990年：地下研究施設建設開始 1992年：安全評価書(SKB91)、SKB研究開発実証計画公表 1993年：予備的サイト特性調査開始 2000年：オスカーシャム、エスタマ、ライエルブの３ヶ所についてサイト調査申請 **Decided Forsmark**	2012年：実証処分 2020年頃：全面運転開始 crystalline bedrock (500m deep)
日本 JPN	ガラス固化体	花崗岩 堆積岩	300m 以深	1989年：研究開発の重点項目とその進め方（原子力委員会） 1992年：第１次とりまとめ（H3レポート） 1999年：第２次とりまとめ 2000年：第２次取りまとめの国による評価 2000年：特定放射性廃棄物の最終処分に関する法律、公布	平成14年：候補地公募開始 平成20年代前半頃：精密調査地区の選定 平成30年代後半頃：最終処分施設建設地の選定 平成30年代後半～：処分場の設計、処分場の建設 平成40年代後半頃：最終処分の操業開始

http://www.iae.or.jp/energyinfo/energydata/data3044.html

Geologic Repository for High-Level Radioactive Waste

High-Level Radioactive Waste at Yucca Mountain, Nevada, US

http://www.ocrwm.doe.gov/repository/index.shtml

Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada

U.S. Department of Energy
Office of Civilian Radioactive Waste Management
February 2002

http://adamswebsearch2.nrc.gov/idmws/ViewDocByAccession.asp?AccessionNumber=ML032690321

Final Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada

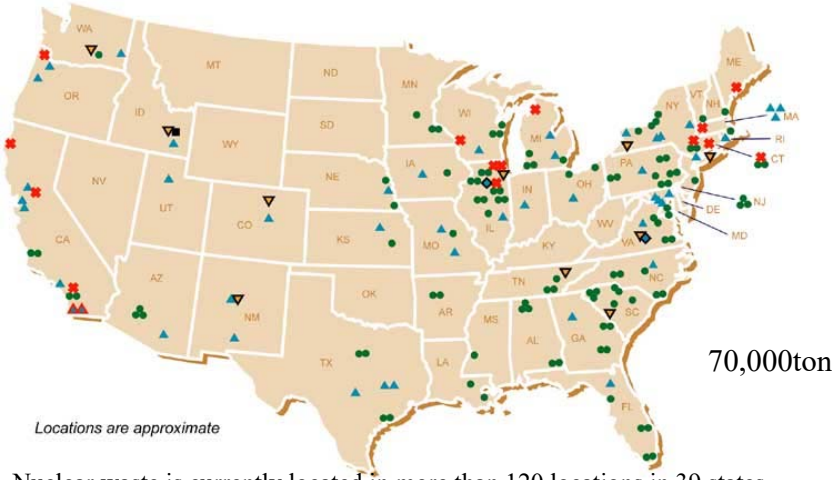
http://adamswebsearch2.nrc.gov/idmws/ViewDocByAccession.asp?AccessionNumber=ML081750191

DOE's License Application for a High-Level Waste Geologic Repository at Yucca Mountain(2008.6)

Construction & receiving HLRW

Cancelled on March 4, 2010 by President Obama

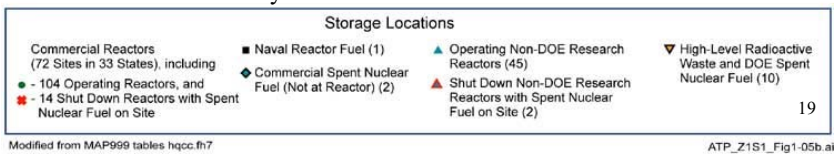
Locations of Spent Nuclear Fuel and High-Level Radioactive Waste Destined for Geologic Disposa



70,000ton

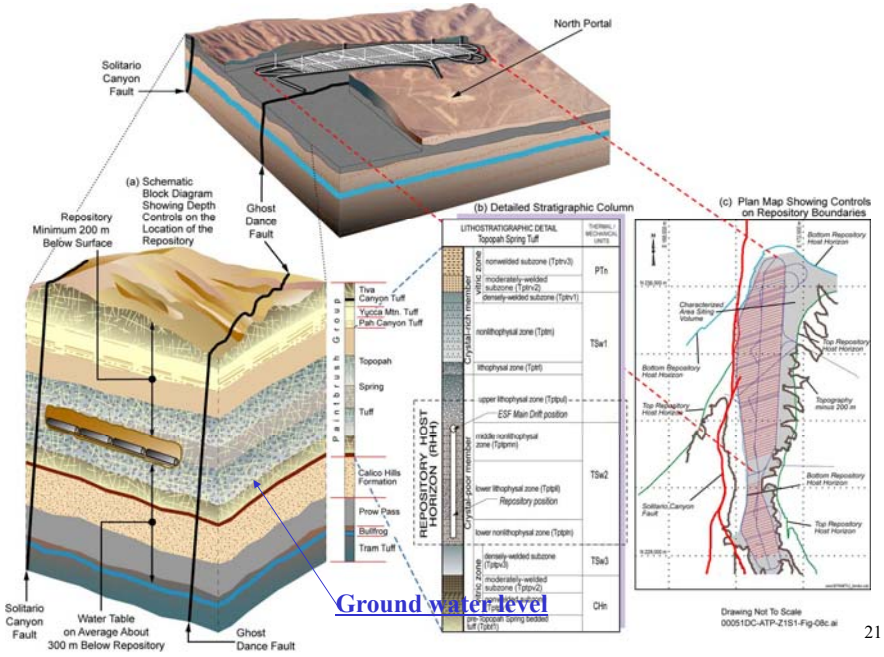
Locations are approximate

Nuclear waste is currently located in more than 120 locations in 39 states

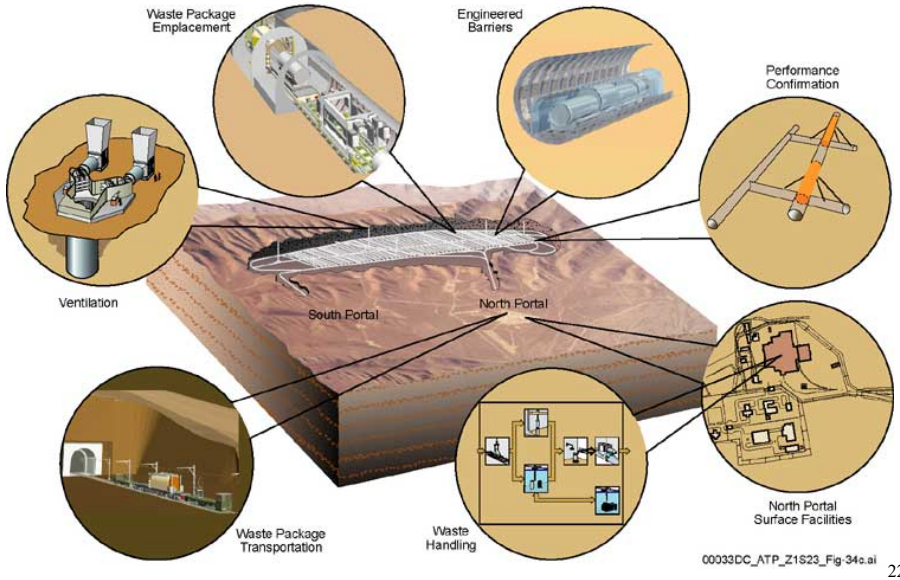


Map Showing the Location of Yucca Mountain and Major Physiographic Provinces of the Southwest

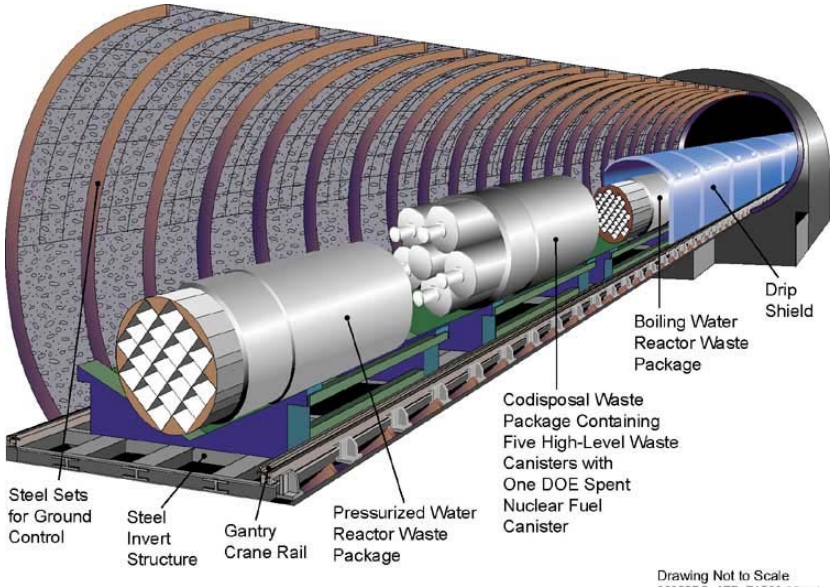
Layout and Boundaries of the Potential Repository



Proposed Monitored Geologic Repository Facilities at Yucca Mountain



Schematic Illustration of the Emplacement Drift with Cutaway Views of Different Waste Packages



DESCRIPTION OF THE SITE CHARACTERIZATION PROGRAM AND THE YUCCA MOUNTAIN SITE

•Key issues in the scientific and engineering for site characterization Investigations

- **•Integrated site model**; under huge number of scenarios for ***TSPA***
- **•Unsaturated zone flow and transport**;
- •Near-field environment;
- •Biosphere;
- •Waste package degradation
- •Waste form degradation
- **•Engineered barrier system degradation, flow and transport**
- **•Saturated zone flow and transport**
- •Disruptive events (volcanic/seismic hazards).

Site characterization tests and analyses

•Surface-based mapping, sampling, and testing of **geologic and hydrologic features and properties**

•Surface-based and **borehole** geophysical testing at both regional and site-specific scales

•**Geologic, hydrologic, and geochemical** sampling and testing in the Exploratory Studies Facility and the ECRB Cross-Drift (Enhanced Characterization of the Repository Block)

•Studies of **hydrologic** processes and investigations of coupled **thermal-hydrologic-geochemical-mechanical** processes in the Exploratory Studies Facility and the ECRB Cross-Drift

•Characterization of geologic and hydrologic **long-term borehole monitoring properties** from borehole studies and of hydrologic properties

Site characterization tests and analyses (contn.)

•Surface-based, borehole, and Exploratory Studies Facility studies of hydrologic and geologic properties of **faults and fractures**, as well as their distribution

•**Hydrologic testing** in the Calico Hills **hydrogeologic unit** at the Busted Butte test facility

•Regional geologic studies and trenching for **seismic and volcanic hazard studies**

•**Meteorological** monitoring and modeling

•Surface environmental studies, including **biological and ecological investigations**

Site characterization tests and analyses (contn.)

•**Geotechnical investigations**, including **in situ and laboratory testing** of soil properties

•**Seismic monitoring and seismic hazard studies** to address the **potential for, and characteristics of, earthquakes** that could affect the potential repository

•**Laboratory geochemical tests** and **analyses of the transport characteristics of water and rocks** under ambient and potential repository conditions

•**Laboratory chemical tests** and analyses of **the dissolution properties of waste materials** under ambient and potential repository conditions

•**Laboratory physical tests of the mechanical properties and behavior of rocks** under ***potential*** repository conditions

Site characterization tests and analyses (contn.)

•**Laboratory testing of materials planned for use in the repository** under potential repository conditions

•**Development of conceptual and numerical models**, and verification and validation of **hydrologic, transport, and coupled process models**

•Performance assessment **modeling of repository behavior**

•Analogue studies of **hydrologic and geologic processes**

High Level Radioactive Waste Disposal

Interdisciplinary

Total System Performance Analysis (TSPA)

Various scenarios

_Types of waste:

Radionuclides (fission products, actinides) :
radionuclide longevity, solubility, and transport affinity
(half decay period, sorbing property, mobility in groundwater)

Considered event:

Natural conditions:
Normal, destructive (Volcanic activity, seismic activity)
manmade conditions: invasion

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.
.

Similar Reports for HLRW Repository

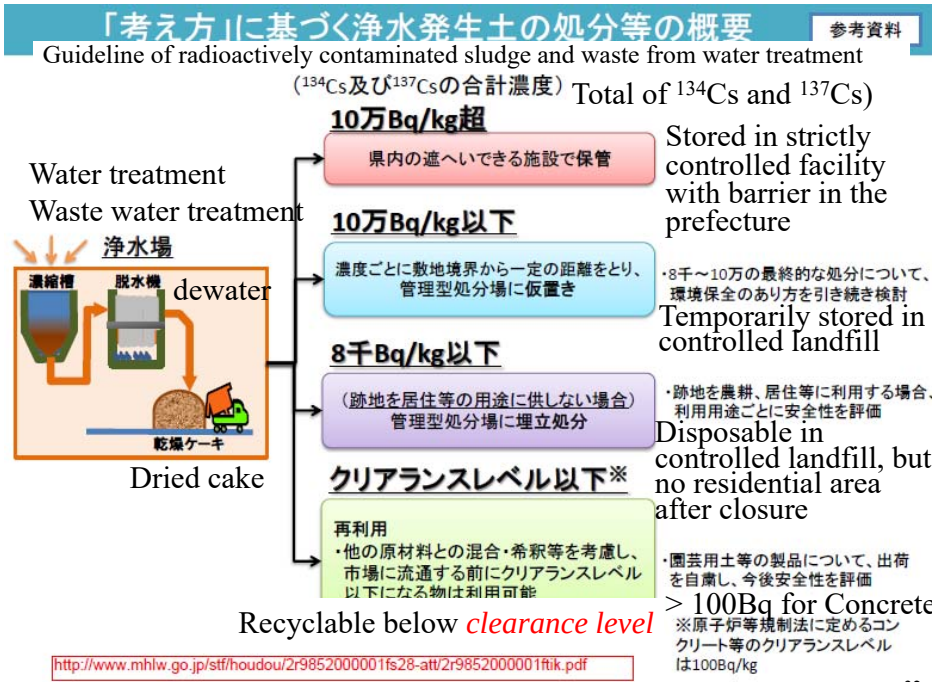
http://www.numo.or.jp/en/reports/

•Development of Repository Concepts for Volunteer Siting Environment construction and after closure

•Evaluating Site Suitability for a HLW Repository (Scientific Background and Practical Application of NUMO's Siting Factors)

Radioactively contaminated wastes
by the accidents of Fukushima No.1 NPP

- Surface soils
- Sewage sludge
  (very high concentration at Fukushima)
- Concretes
- Woods
- Agricultural products (??)

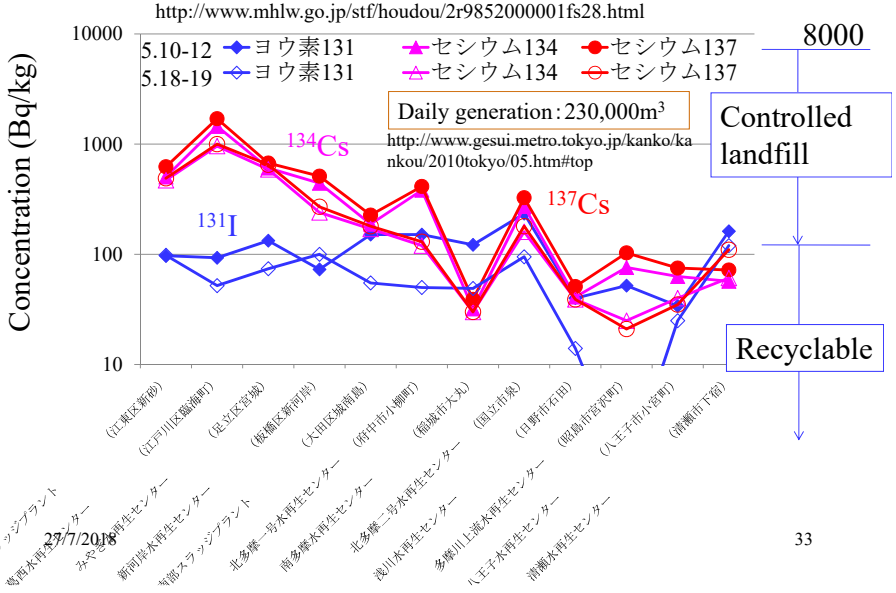


Contamination of level of sewage sludge in Tokyo

東京都下水道局http://www.gesui.metro.tokyo.jp/oshi/infn0517.htm

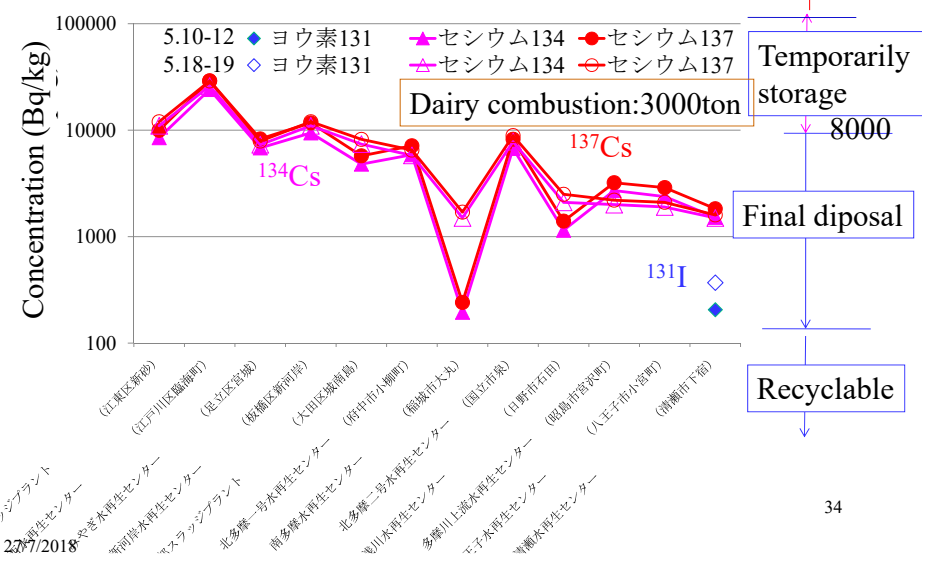
汚泥に関する取り扱い基準（原子力災害対策本部）

http://www.mhlw.go.jp/stf/houdou/2r9852000001fs28.html



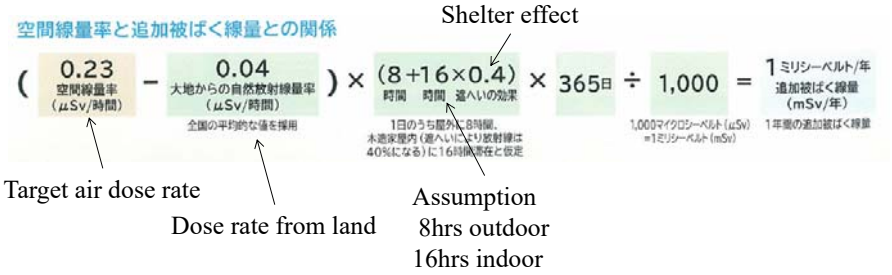
Contamination level of ash of sewage sludge in Tokyo

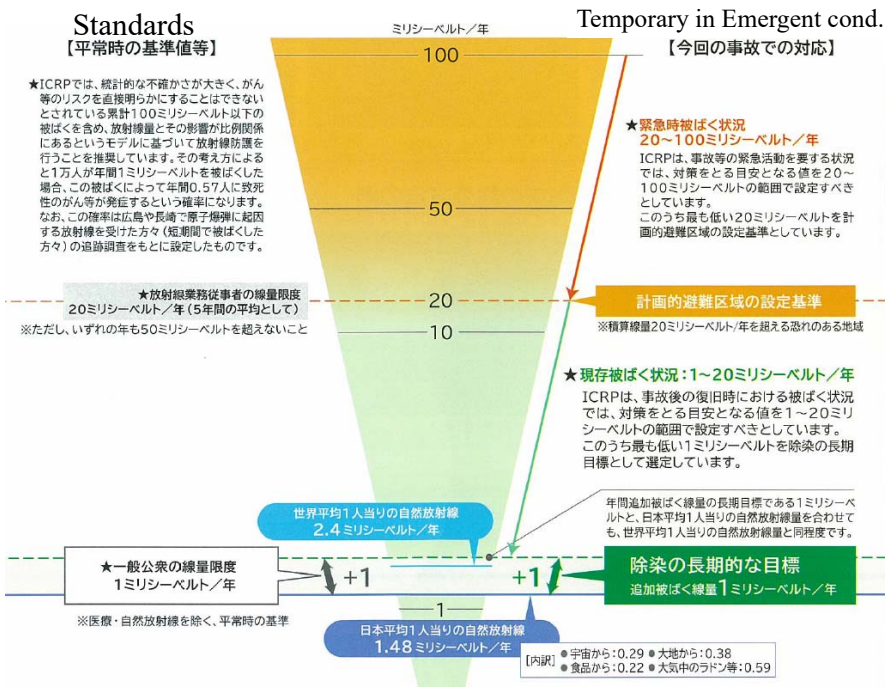
東京都下水道局http://www.gesui.metro.tokyo.jp/oshi/infn0517.htm



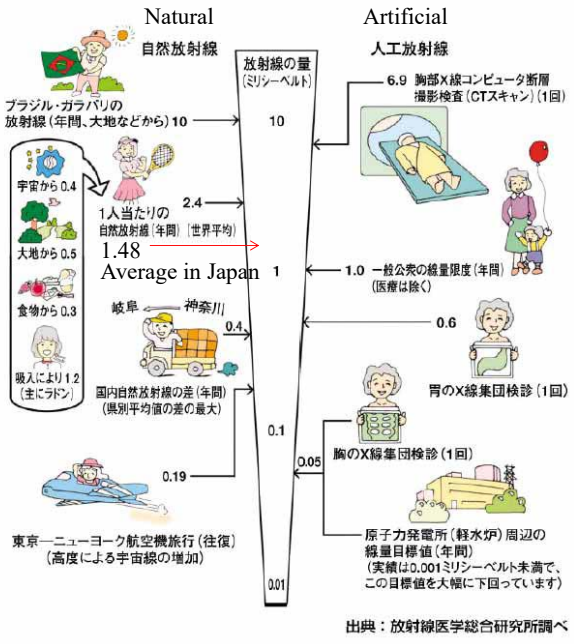
Decontamination of Radioactive Materials Caused by Fukushima Daiichi NPP

Long term target of air dose rate for the decontamination





Radiation in daily life



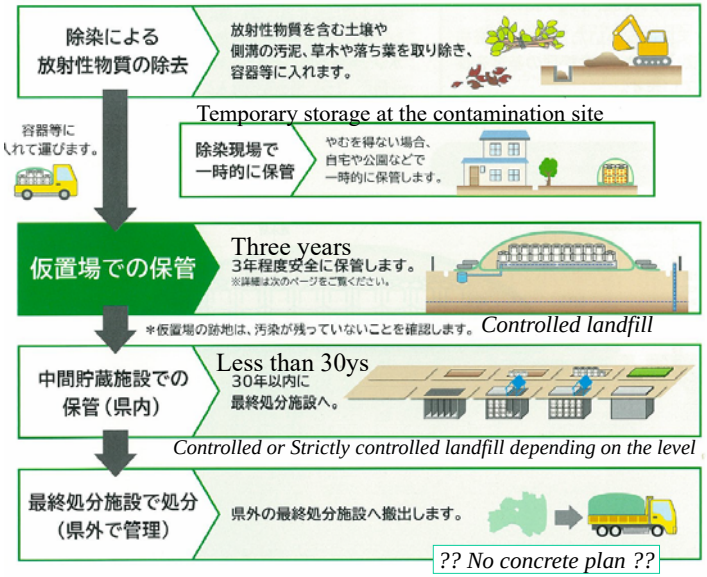
Roadmap of decontamination, MOE

Removal of RAM

Temporary but controlled storage facility

More secured Intermediate storage facility

Final disposal Facility, out of Fukushima



除去物は、中間貯蔵施設で保管した後、30年以内に福島県外の最終処分施設へ搬出されます。

Temporal storage

厳格な
安全対策基準の採用

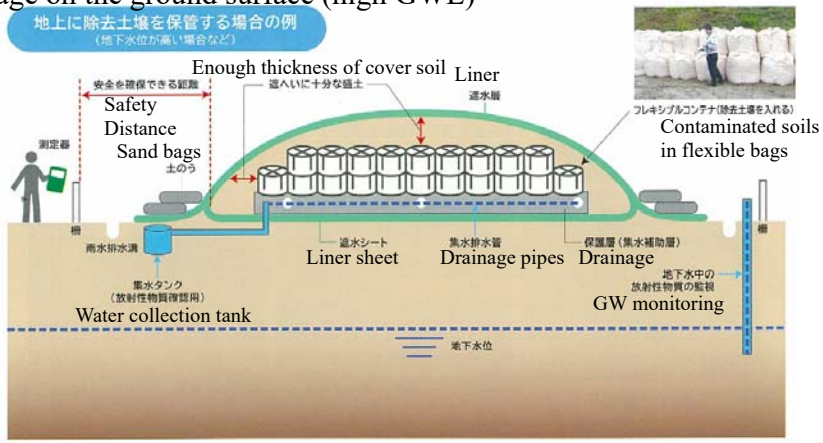
皆さまにご安心いただくため、厳格な施設設計と、安全管理の基準を採用しています。

Prevention air spreading and leakage

放射性物質の飛散・流出・地下浸透の防止

除去土壌は水を通さない層(遮水シート等)の上に容器(フレキシブルコンテナ等)に入れて置きます。覆土をするとともに、遮水シート等で覆います。これにより、除去土壌自体の飛散・流出を防ぎ、さらに雨水等の流入と地下水等の汚染を防ぎます。

Storage on the ground surface (high GWL)



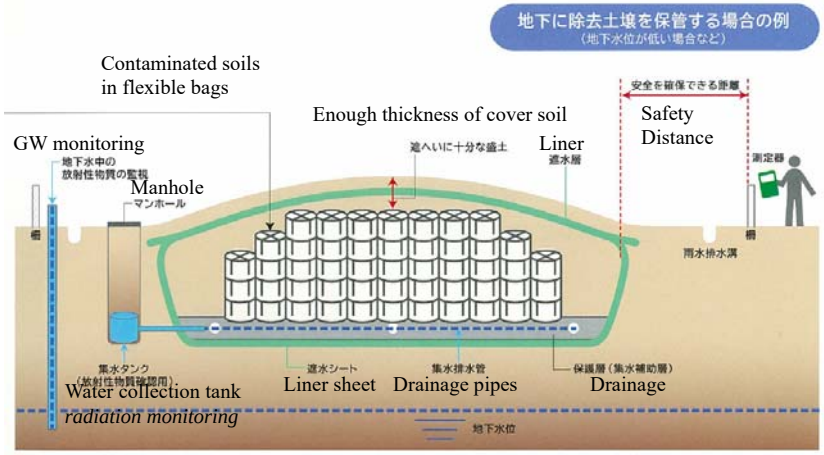
Cut-off of radiation by barrier material

遮へいによる、放射線の遮断

覆土や土のうで囲むなどの方法で、仮置場の敷地境界での空間線量率が、周辺と同水準になる程度まで遮へいを行います。

Containment efficiency

Underground Storage (lower GWL)



Intermediate storage
中間貯蔵

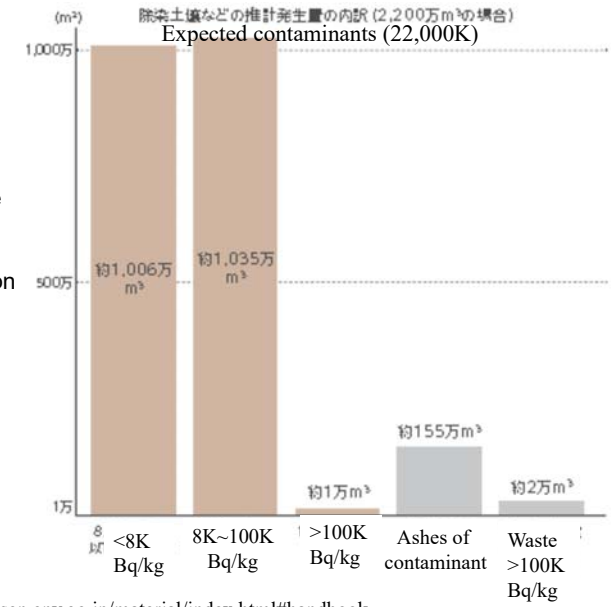
http://josen.env.go.jp/material/index.html#handbook

環境省パンフレット:除染土壌などの中間貯蔵施設について

RD contaminated soils and others

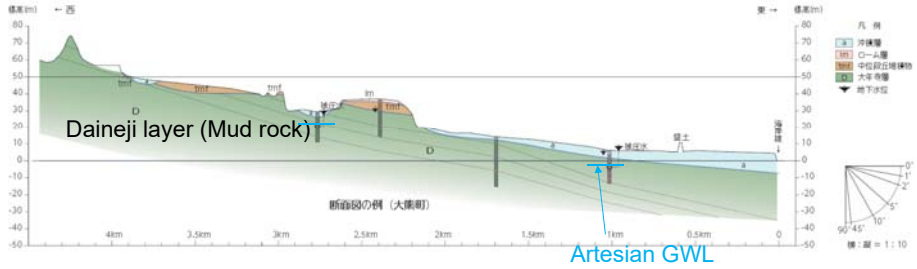
16,000K～22,000Km3

soils → combustible materials → volume reduction by combustion → separation → Low-, Mid-, High-level → Different facility

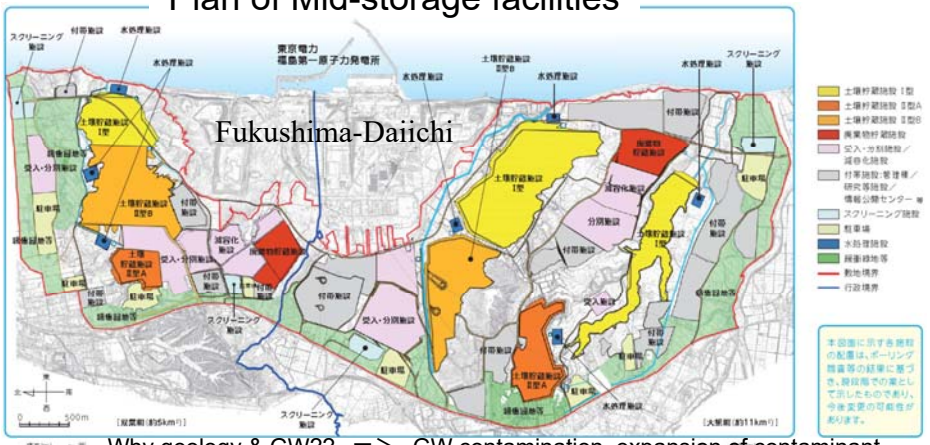


http://josen.env.go.jp/material/index.html#handbook

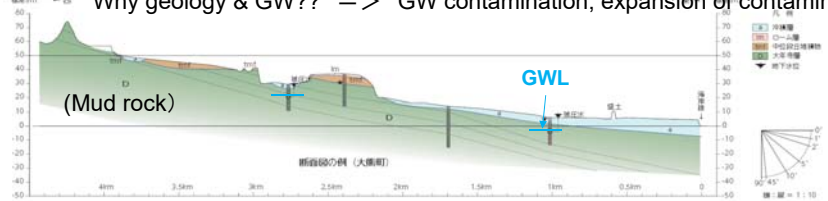
Geology and groundwater at disposal site



Plan of Mid-storage facilities

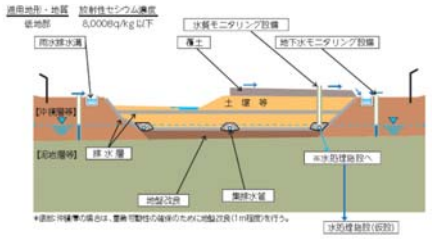


Why geology & GW?? ＝＞ GW contamination, expansion of contaminant

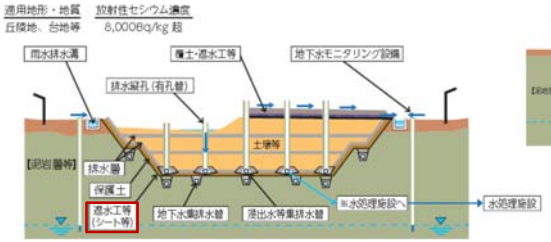


Storage facility

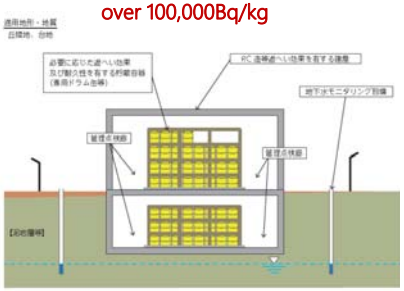
Soils (type I) Less than 8000Bq/kg



Soils (Type ⅡA) 8000~100,000Bq/kg



Contaminant wastes
over 100,000Bq/kg

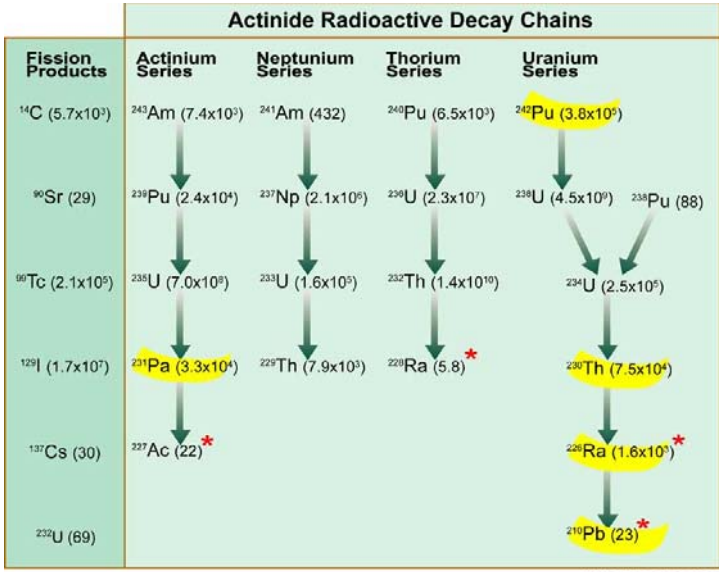


Other problems by Fukushima Daiichi

- Generation of contaminated water and its storage and de-radiation
- Ground and Sea water contamination

Possible measures
for
Secure storage
Reduction of contaminated water

All Radionuclides Considered in the TSPA model, Showing Decay-Chain Relationships (with Half-Lives in Years)



http://www.ocrwm.doe.gov/documents/ser_b/index.htm

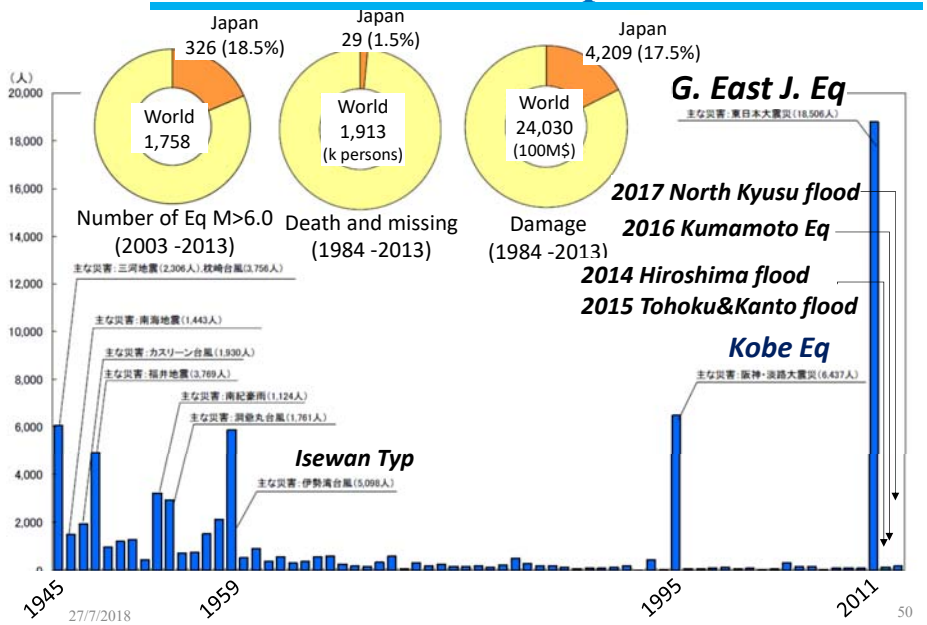
Intensity of radio activity

		Intensity (MBq/g)	Half decay
Natural nuclides	^{238}U	0.012	4.56B yrs
	^{40}K	0.26	1.25B yrs
	^{226}Ra	$3.7x10^4$	16M yrs
Nuclides after fission	^{239}Pu	1.4×10^3	24K yrs
	^{137}Cs	3.2×10^6	30 yrs
	^{131}I	4.6×10^9	8 days
	Xenon ^{133}Xe	6.9×10^9	5.3 days
	Krypton ^{88}Kr	2.9×10^{12}	2.8 hrs

Disaster Wastes

Impact of Debris and Sediments caused by Devastating Natural Disaster - Preparation for Sustainable Solid Waste Management, Lessons Learnt-

Natural disasters in Japan after WW II



White paper on Disaster Management (2012), Cabinet Office, Gov JP

今も多くのがれきが散乱し、海水も残ったままの無残な姿の波の引いた陸地＝宮城県岩沼市で［写真提供：毎日新聞社］

Miyagi, Iwanma

宮城県岩沼市

岩手県釜石市大渡町商店街

Iwate
Ishinomaki

重機を使ったがれきの撤去作業
釜石市

Iwate
Rikuzentakada

屋根の高さまでつみあがったがれきの中を捜索する大阪府警の救助隊：陸前高田市

What can be seen in the photos?

Huge Debris, Disaster wastes

Argent and early stage

Obstacles in rescue
&
Hindering recovery and restoration
Physically and Mentally

UWP

Concerns in long term

Environmental problems
Pollution / Modification of city planning

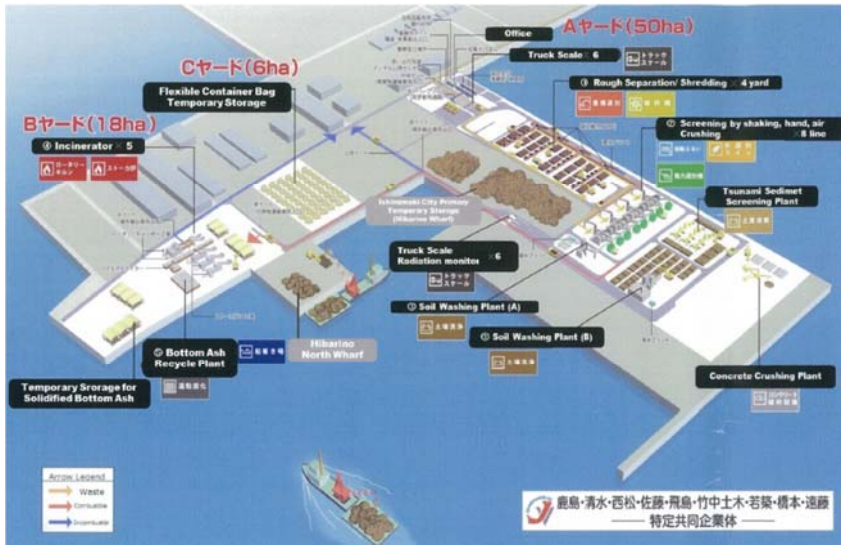
Disaster wastes: Tohoku Eq. vs Kobe Eq.

	2011 Tohoku E.	1995 Kobe Eq.
Waste volume	Debris: 20,2Mton T. Deposits: 11Mt	Debris: 20 Mt (including 5.5 Infra S.)
Wide area disposal	Plan（2.5Mt) => 0.62Mt	About 20% (4Mt)
Disposal: 1year 2years 3years	7% 60%、97% 78 – 100%	50% 100%
Cost	50,000- 60,000yen/ton 1,700 B yen	22,000 yen/ton 400 B yen
Main debris	Houses and buildings (t collapse 104,900)	Houses and buildings (t collapse 126,400)
Cause of wastes	Tsunami	Strong ground motion
Other	Mixing waste hard to segregate 、Tsunami deposits	Rather uniform
	Concern about radio contamination	

Primary storage yard
Kawauchicho, Ishinomaki, Miyagi

http://kouikishori.env.go.jp/

Secondary waste storage and processing yard, Inshinomaki, Miyagi



Pamphlet of Kajima JV

Typical debris processing

Pamphlet of Kajima JV

① Left: Rough Separation, Right: Shredding

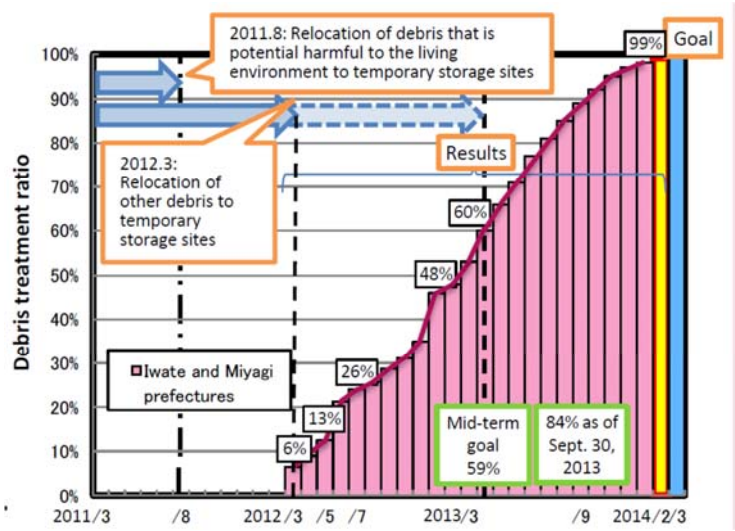
② Left: Screening by shaking, Right: by hand

③ Soil Washing Plant (Left: A plant , Right: B plant)

④ Incinerator (Left: Stoker, Right: Rotary Kiln)

⑤ Bottom Ash Recycle

Plans and results for treatment of debris in coastal municipalities of Iwate and Miyagi prefectures

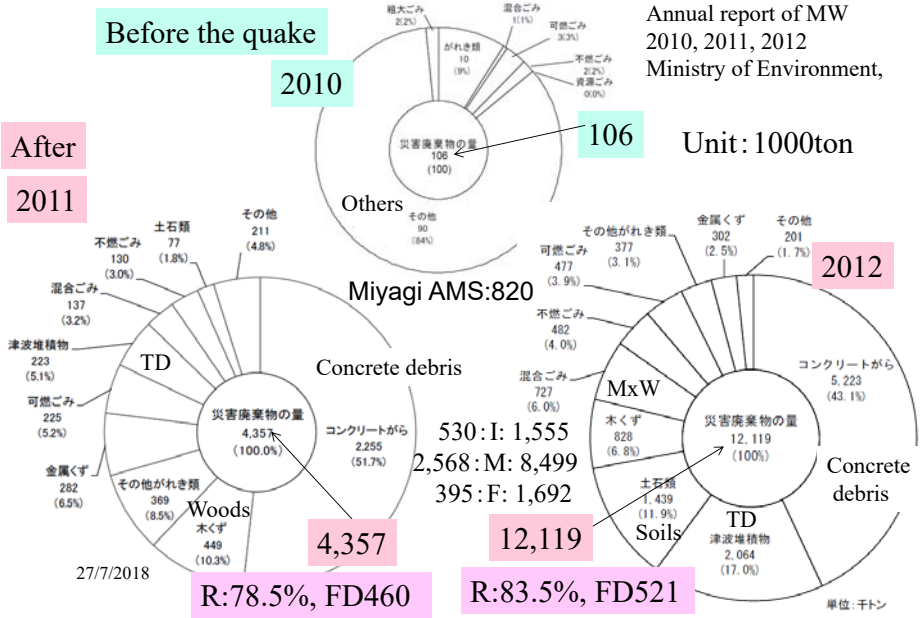


http://kouikishori.env.go.jp/ Ministry of Env.

Disaster wastes disposed before and after the quake

Annual report of MW 2010, 2011, 2012 Ministry of Environment,

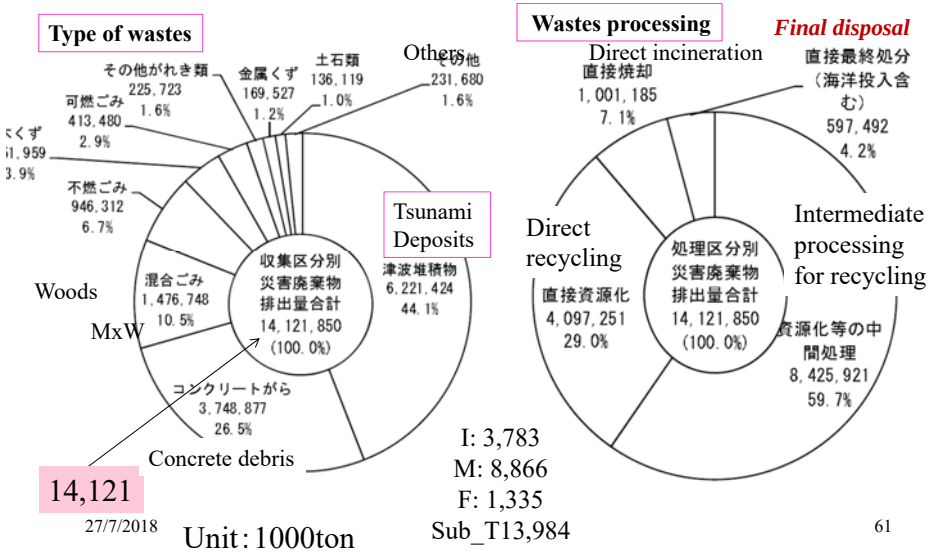
Unit: 1000ton



Disaster wastes disposed three years after the quake

2013

2013 Annual report of MW, Ministry of Environment,



Super typhoon Haiyan（Yolanda)

2013.11.3~11 (Peak 11/8)

Category 5：Super typhoon
Minimum pressure：895hPa
Wind speed：（1 mins） 315km/h (87.5m/s)
（10 mins） 230km/h (64m/s)
（Instant） 378km/s (105m/s)
Height of storm surge：5- 6m
Debris：1,100,000 ton(estimated from, truck number）
Disposal of debris：initiated by UNDP
Objective:
emergency（clearance of road）
=>temporary storage=>dumping site=> long term？

Leyte Island
Philippines

Moment after the typhoon

Nov. 11, 2013



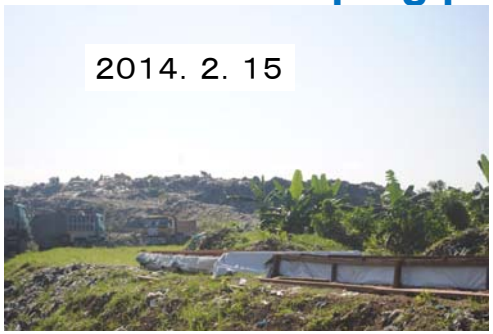

3 months after the typhoon

Feb. 15, 2014




Tacloban and final disposal site

Final dumping place ：Sto Nino




5 months after the typhoon

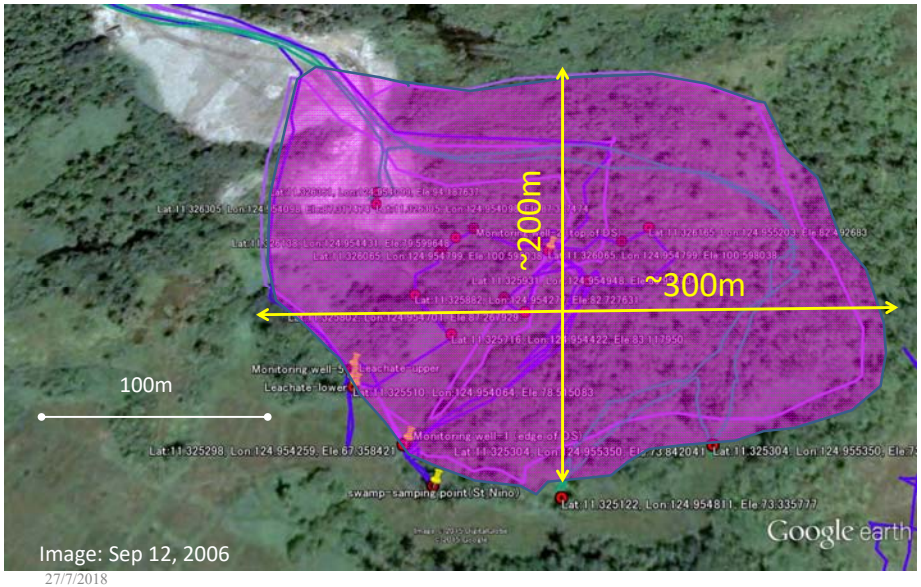
April ，2014




Sto Nino, 2014.6.11

Well managed and disposed in about a half year

St Nino dumping site



Surrounding environment

Concerns

Long terms effect

No data??

Change of Surrounding after the disaster

After **3** months

5 Months

7 Months

On-going landfilling

14 months

Goggle Earth image two year after the disaster

ムサ アハマド

Change of city plan

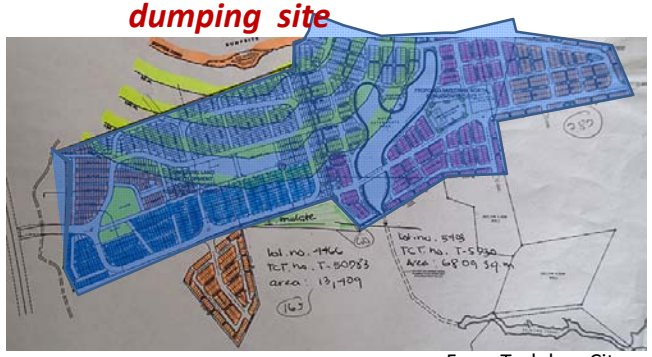
Original plan:

Sanitary landfill + Eco Town

After disaster:

Open dumping + housing complex for relocation

dumping site



From Tacloban City

Concerns: Effects of Dump site??

- Housing very close to DS at down stream side
- Rapid dumping without any measures for environmental protection.
- Type of disaster wastes different from ordinary ones?
  Chemical composition of leachate?
- Effects of leachate to surface water and ground water?

But

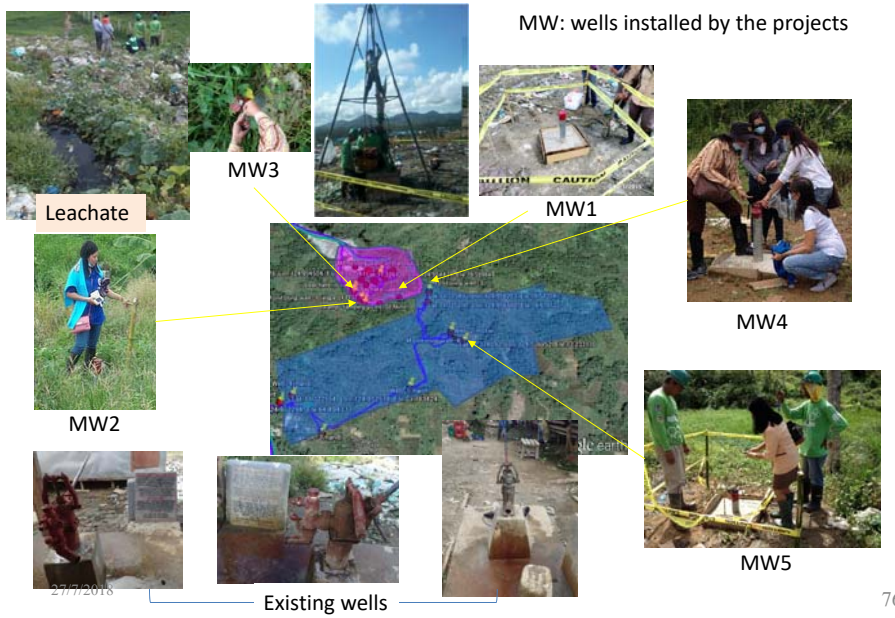
- Almost no data and info.
- Effect of leachates may appear long time.

As Main research activity

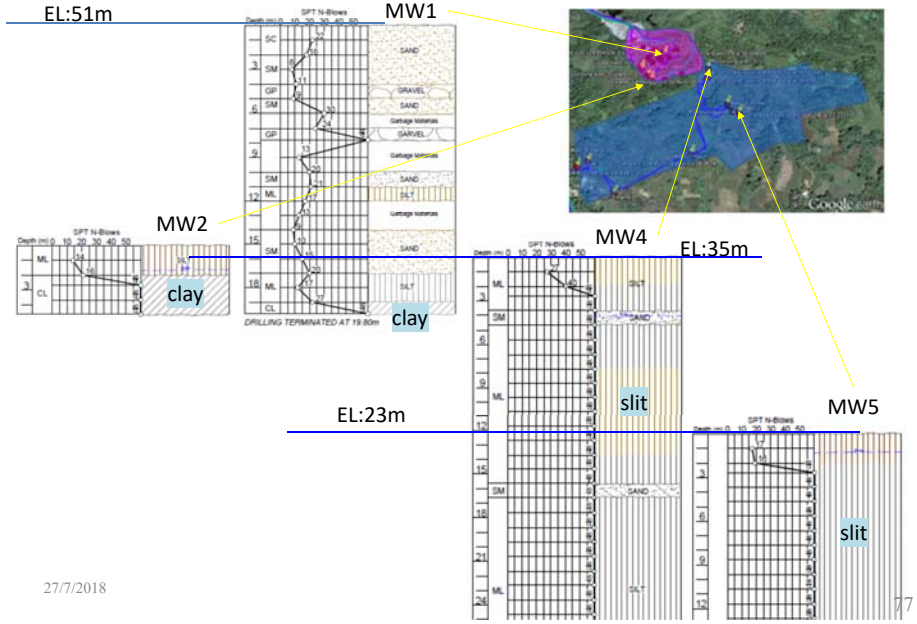
- Monitoring of water environment, leachate, swamp, creek, ground water (well (existing, new)

Site investigation and well installation

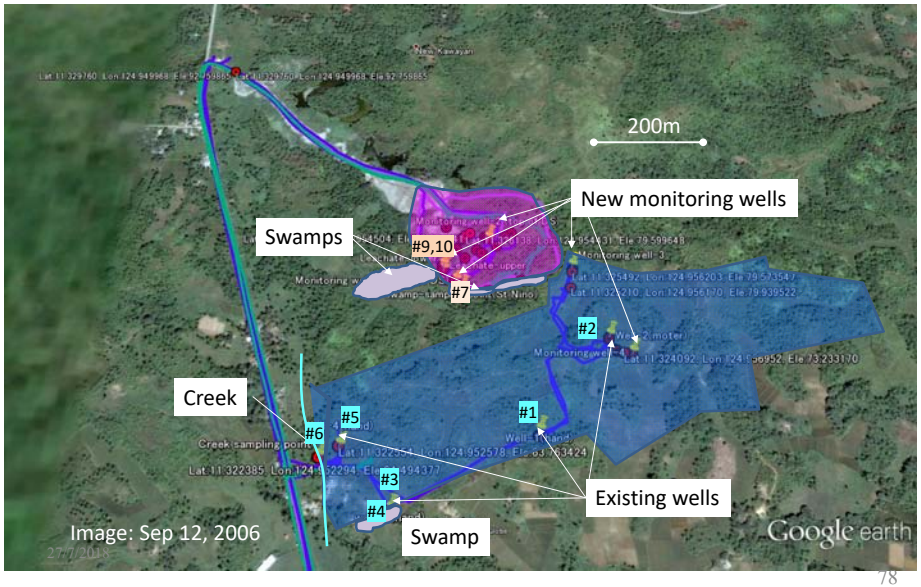
MW: wells installed by the projects



Geological conditions



Monitoring Wells and sampling points



Results of preliminary water quality investigation

- Dump site

(mg/L)

	As	Cl^-	NO_3- N	PO_4-P	Ca	K	Na
#9 Leachate	0.009	45	3	2.3	347	118	
#10 Leachate	0.005	25	4.4	1.1	434	142	
#7 Swamp	<0.001	175	2.7	0.41*	42	10	70

(*: total P)

Other HMs (Cd, Cr, Pb, Hg) are all below DL.

Need monitoring of the leachate properties

- Housing site

	As	Cl^-	NO_3-N	Total P	Ca	K	Na
#1 Housing well	<0.001	48.6	0.01	<0.01	21.1	33	28.9
#2 Batching well	<0.001	4.1	0.27	1.26	35.4	2.23	40.7
#3 Housing well	<0.001	6.6	0.33	1.36	31.5	1.46	31.6
#4 Swamp	<0.001	9.5	0.62	1.28	6.8	3.33	11.4
#5 Habitat well	<0.001	5.3	0.03	0.42	32.1	<0.02	25.1
#6 Creek	<0.001	9	0.73	1.16	14.7	2.84	12.7

No clear evidence of contamination by Leachate.

Dilution for surface water
Slow migration in subsurface (GW)

Need long term monitoring.

Comparisons with other LFs
Sai Noi LF Nontaburi Prov. Thailand

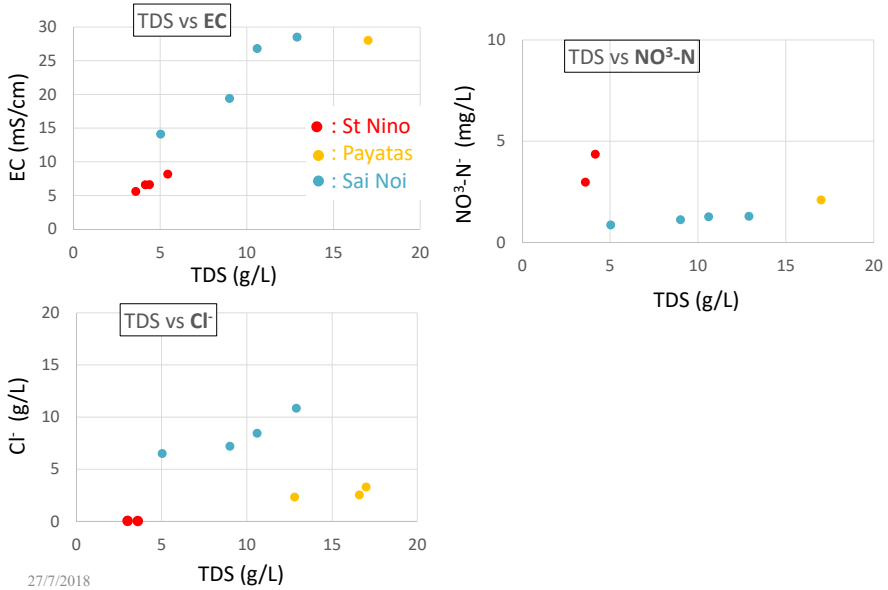
Comparisons with other LFs
Payatas CDF, Quezon, Philippines

Accepting 1,100ton/ day
House hold garbage

Comparisons

- St Nino: Disaster wastes
  400 trucks/day => ~1,600 ton/day
- Sai noi: Municipal Solid wastes (garbage)
  700 ton/day
- Payatas: Municipal Solid wastes (garbage)
  1,100ton/day

Comparisons of leachate quality with other LFs



Conclusions

Disposal strategy and management of Disaster W

Depending on

- Scale, type of disasters

- Country (developing level, economy, social, etc.)

Impacts

- last rather long and not visible => proper evaluation

We must be aware of the limitation of the power of human being against to the power of nature.

Prevention ➔ Reduction

Preparedness=>need info on all related issues

??