Workshop for Sustainable Remediation
Tokyo, Japan, May 2018

Towards sustainable soil management:
Case studies of the reuse of tsunami deposits and excavated soils with natural contamination
持続可能な土の管理に向けて ー 津波堆積物や自然由来土壌の有効利用を事例として

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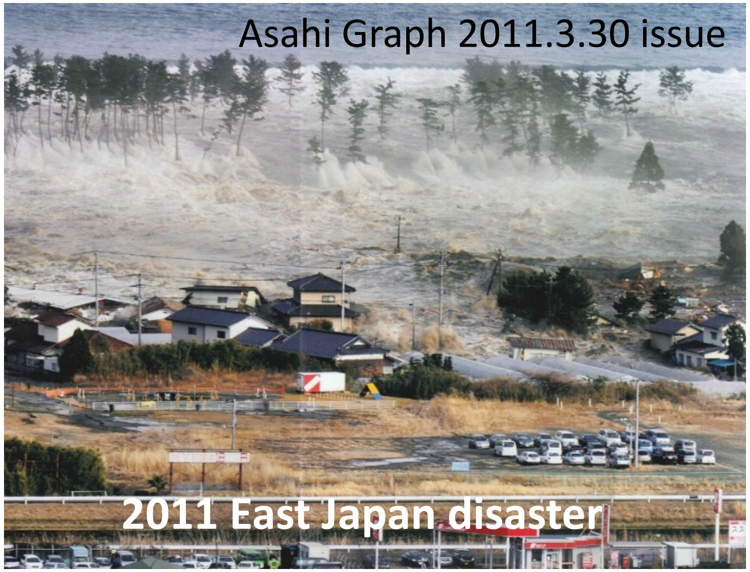
Topics

- ✓ **Tsunami deposits**, or "**recovered soils**" obtained from disaster debris at 2011 East Japan earthquake

  2011年東日本大震災で発生した災害廃棄物・津波堆積物から再生した分別土の利用

- ✓ **Excavated soils** with natural contamination generated from construction works

  建設工事で発生する自然由来の重金属等を含む掘削土



2011 East Japan disaster and waste generation

- ✓ **Earthquake** at March 11, 2011, Mw = 9.0 at Tohoku coast
- ✓ **Tsunami** of ~40 m max. runup & 561 km^2 inundated area

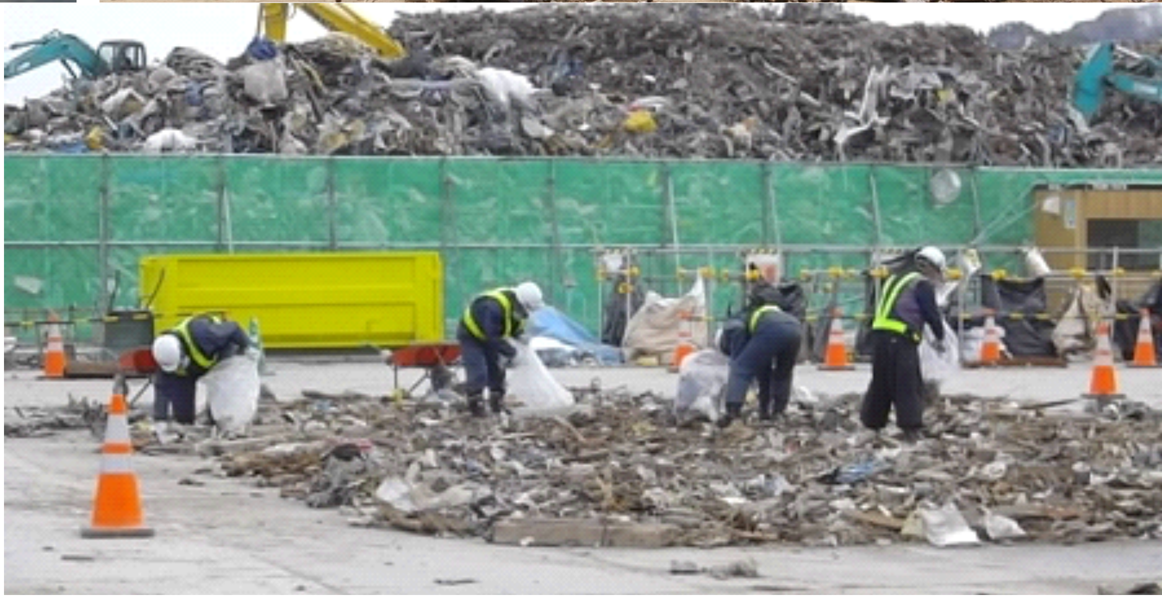
- ✓ **Disaster waste** with **large amount** (~30,000,000 ton), **mixture** of the various materials, and **significant soil fractions** (> 1/3 in weight)
  東日本大震災により3000万トンにのぼる大量の災害廃棄物・津波堆積物が発生した。これらは混合状態であり、約1/3は土砂であった。

Disaster wastes at temporary storage sites

Entrance of advanced treatment site; Manual separation
高度選別現場の入り口／手選別の様子


Weight and type of transported disaster wastes were checked at the entrance (Kessennuma city).
高度選別現場の入り口での受入時確認様子

Separation with operation vehicles (Ishinomaki city)
重機選別の様子


Valuable items were manually selected (Miyako city.)
手選別による思い出の品の選別

写真： 日本建設業連合会

Separation machines　機械選別の様子

写真:　日本建設業連合会


Rotating screen (Otsuchi town)
回転式ふるい


Uni-axial crushing machine 一軸破砕機


Wind separation machine
(Kamaishi city)
風力選別機

Manuarl separation (Minami-sanriku town)
手選別の様子

Treatment of concrete debris and soil-dominant stockpiles
コンクリート塊や土砂系混合物の処理

Crushing of concrete debris (Otsuchi town)
コンクリート塊の破砕

Separation from soil-dominant stockpiles (Yamada town)
土砂系混合物（津波堆積物）の分別

写真： 日本建設業連合会

Basic flow of disaster waste treatment

Collection & transportation
収集と仮置き場への運搬

Rough separation at temporary storage sites
仮置き場での粗選別

Advanced separation at secondary temporary storage sites
二次仮置き場での高度選別

completed in 3 years in most places.

Separated fractions (分別物)

- Metals (金属)
- Wood chips (木くず)
- Crushed concretes (コンクリート)
- Hazardous materials (有害物)
- **Recovered soils** (分別土)

etc

- Recycle (再利用)
- Utilization (有効利用)
- Use in cement (セメント原料)
- Incineration (焼却)
- Landfill (埋立処分)

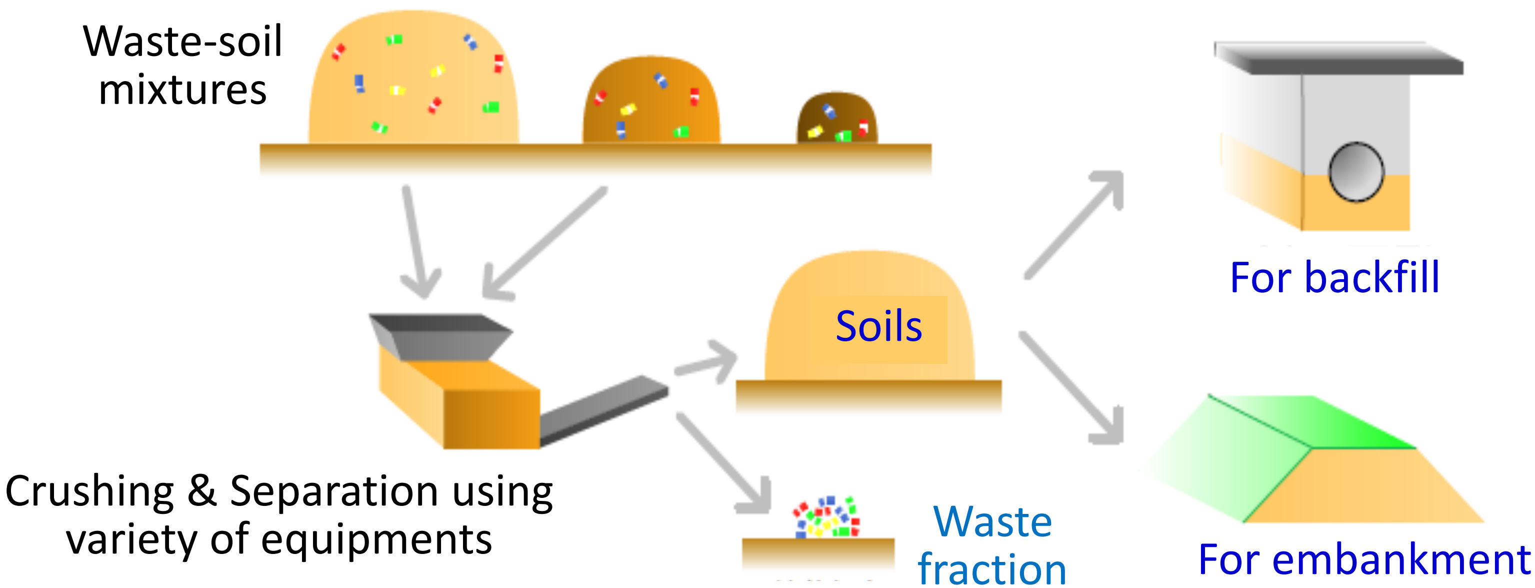
“Recovered Soils” separated from disaster wastes

Utilization of the ”recovered soils” to re-construction works was expected. However, no technical background had existed.

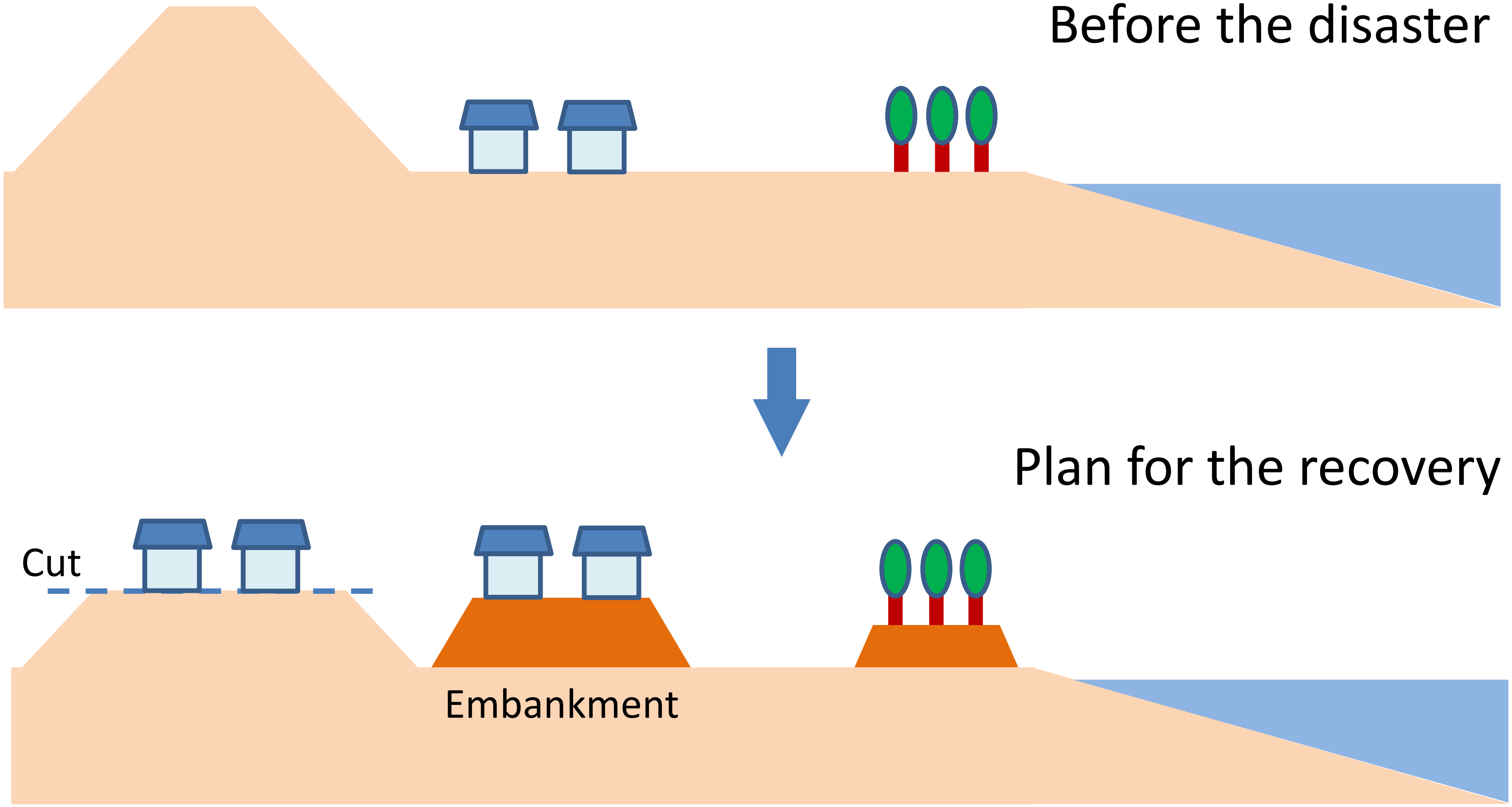
- Properties of the RSs were anticipated, due to the varieties in treatment measures, target quality, original soil properties, etc.

The Japanese Geotechnical Society (JGS) has contributed to the characterization, standardization, and strategic utilization of RSs.

分別土の復興事業への利用が期待された。(公社)地盤工学会が、分別土の物性評価、標準化、有効利用に関して貢献した。



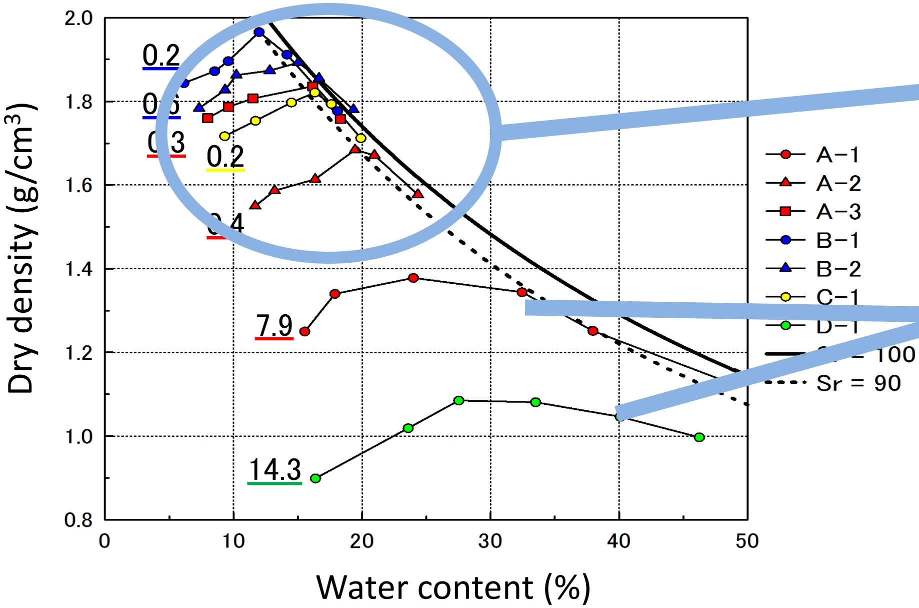
Basic idea of disaster recovery



Re-construction works to create elevated residential, commercial, and green areas require construction materials such as soils (estimated 126 million m^3 for recovery from 2011 disaster).
復興事業で12600万m^3もの土が必要と見積もられていた。

Characterization & standardization of recovered soils

Number: burnable fraction in %



Good compaction properties from **soil-dominant stockpiles**

--> RS Class A

Poor compaction properties from **waste-dominant stockpiles**

--> RS Class B

--> RS Class C (not to be used)

"Technical Manual for the Use of Recovered Materials" was established in Iwate prefecture in 2012.

- ✓ Classification was designated.
- ✓ Evaluation of engineering properties & environmental suitability was required.

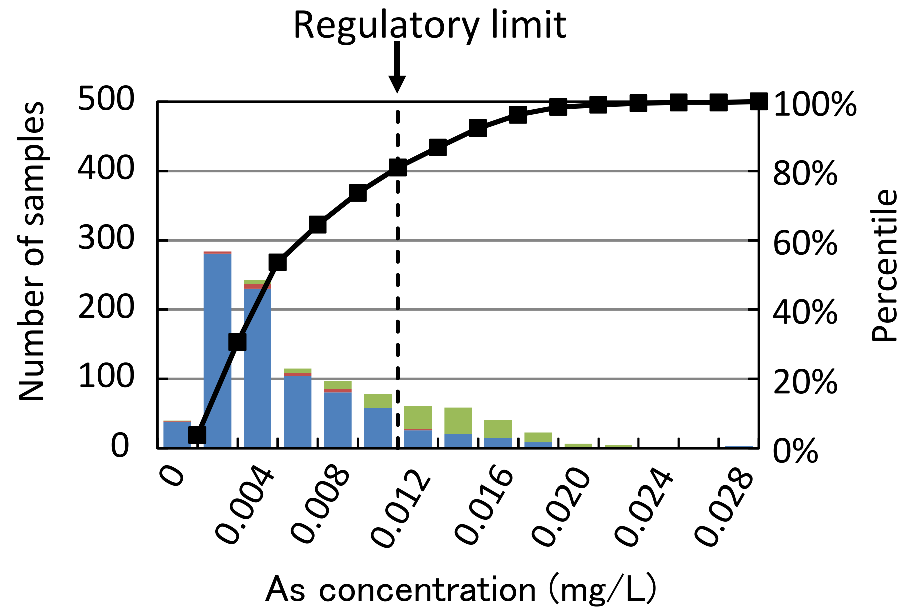
JGS-TC accumulated the experimental data prior to practice, & provided technical advises on the guideline.

「岩手県復興資材活用マニュアル」では、(1) 分別土の分類、(2) 工学特性と環境影響の評価、が示された。地盤工学会も貢献した。

Leaching of toxic elements from recovered soils

- Most of RSs were subjected to the evaluation of environmental suitability.
- Some RSs exceeded the regulatory limits for leaching of As, F, B, & Pb, based on Japanese Leaching Test No.46.

  溶出試験（環境庁告示46号）で、ヒ素、フッ素、ホウ素、鉛で基準を超過する分別土が若干あった。



~20% RS in Kesennuma city exceeded regulatory limit for As (Ohta et al. 2016).

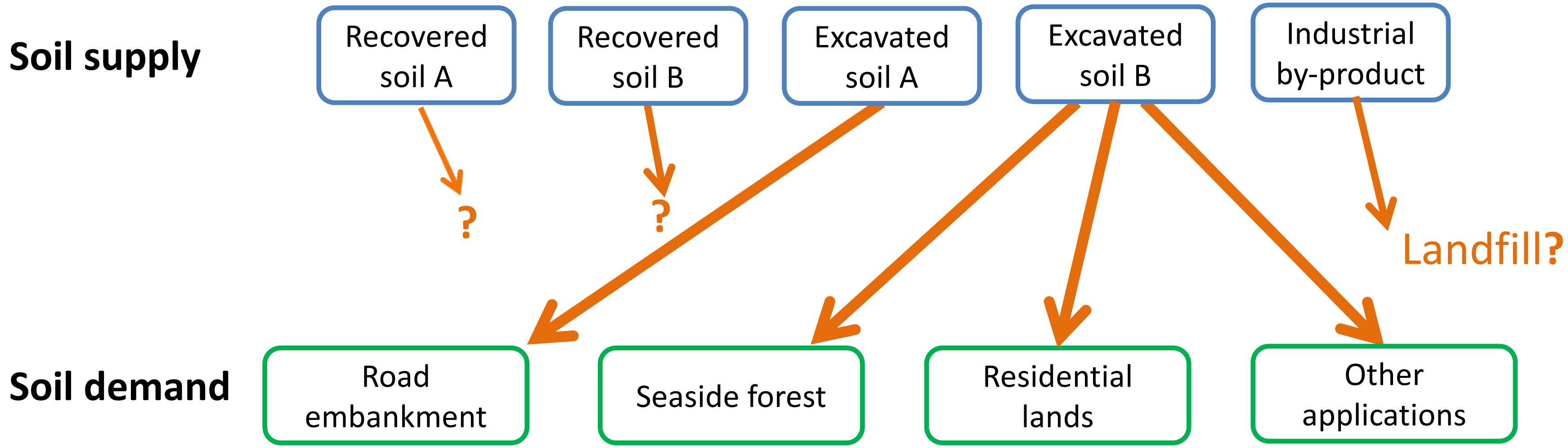
<u>Countermeasures</u>

- Landfill　処分
- Mixing with chemical agent to immobilize toxic elements　不溶化処理
- Use in embankment for public facilities (road, sea dyke etc.)
  道路盛土等への利用

Use of soils in recovery works

Recovered soils were expected to be used, but there were barriers to use them.

- ✓ Cost for storage & transportation
- ✓ Conservativeness for recovered materials, compared to virgin materials
- ✓ Competition with excavated soils
- ✓ Various institutions/companies



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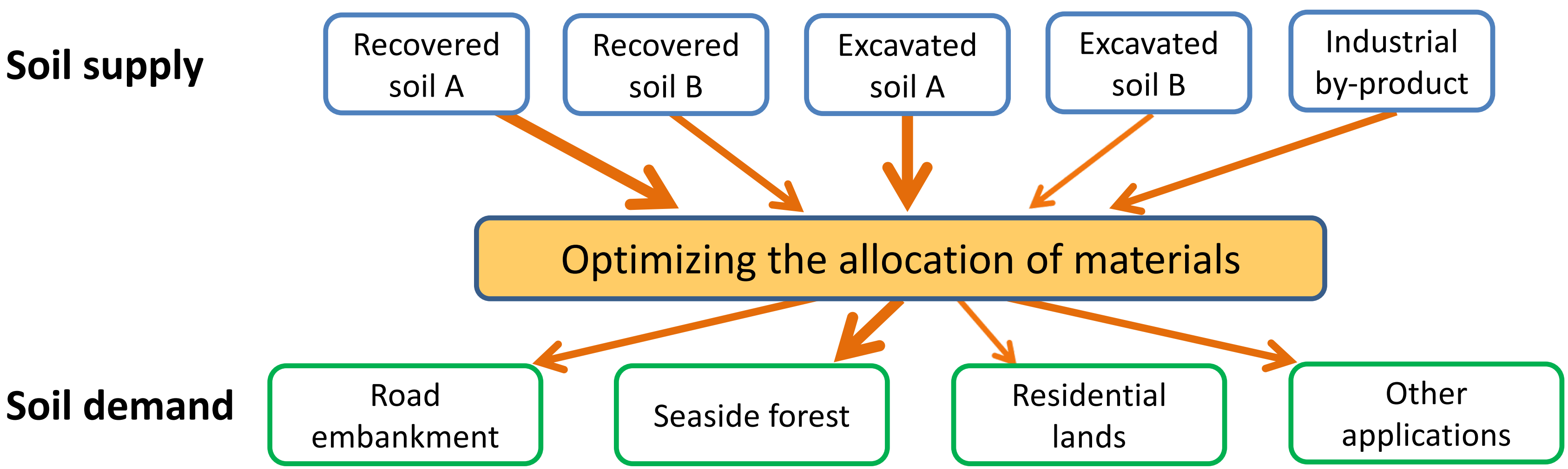
Based on the technical investigations, JGS-TC presented “recommendation,” to tie different governmental & private institutions/sections to achieve the optimized allocation of soils.
地盤工学会は復興資材活用の「提言」を公表した。



Use of recovered soils in Iwate prefecture

- ✓ **RS Class A** (= 880,000 m^3) used for farmland (24%), coastal forest (21%), residential area (14%), green space (14%) etc.
- ✓ **RS Class B** (= 260,000 m^3) used for residential area (37%), coastal forest (23%), road embankment (16%), backfill (12%), etc.

Model embankments were constructed using recovered soils, to monitor mechanical and environmental behaviors.

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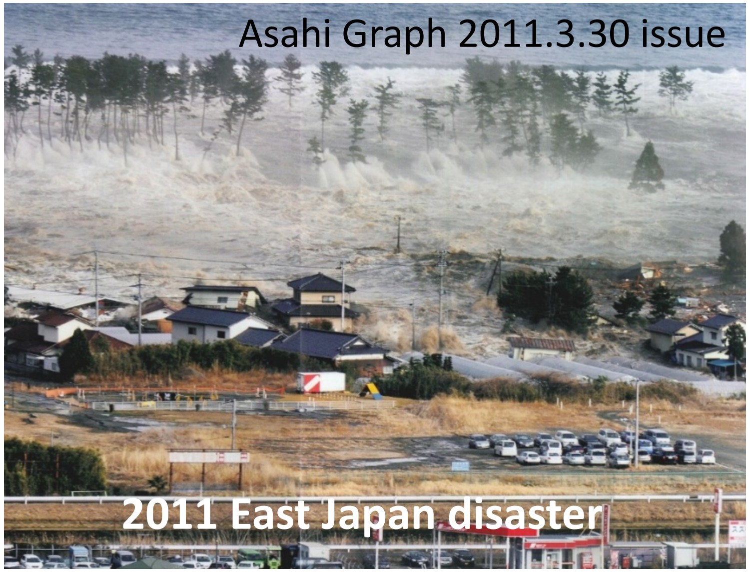
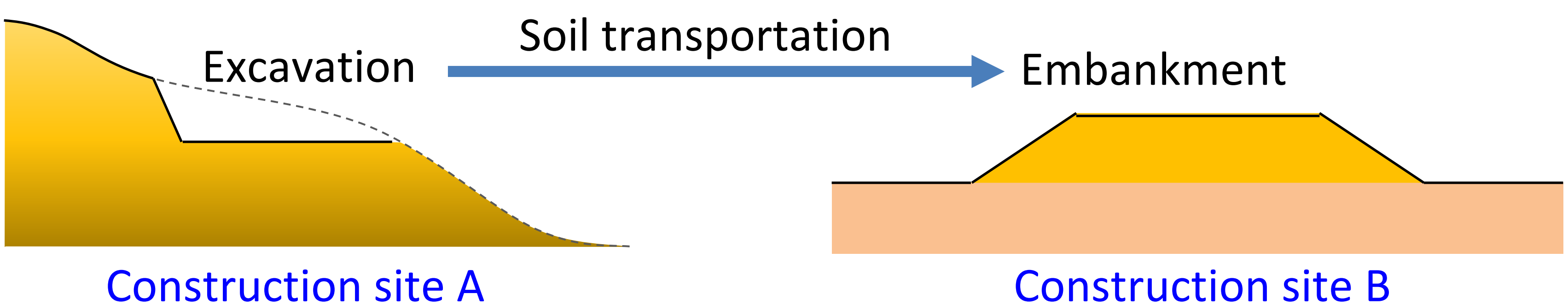


History of national regulations and guidelines

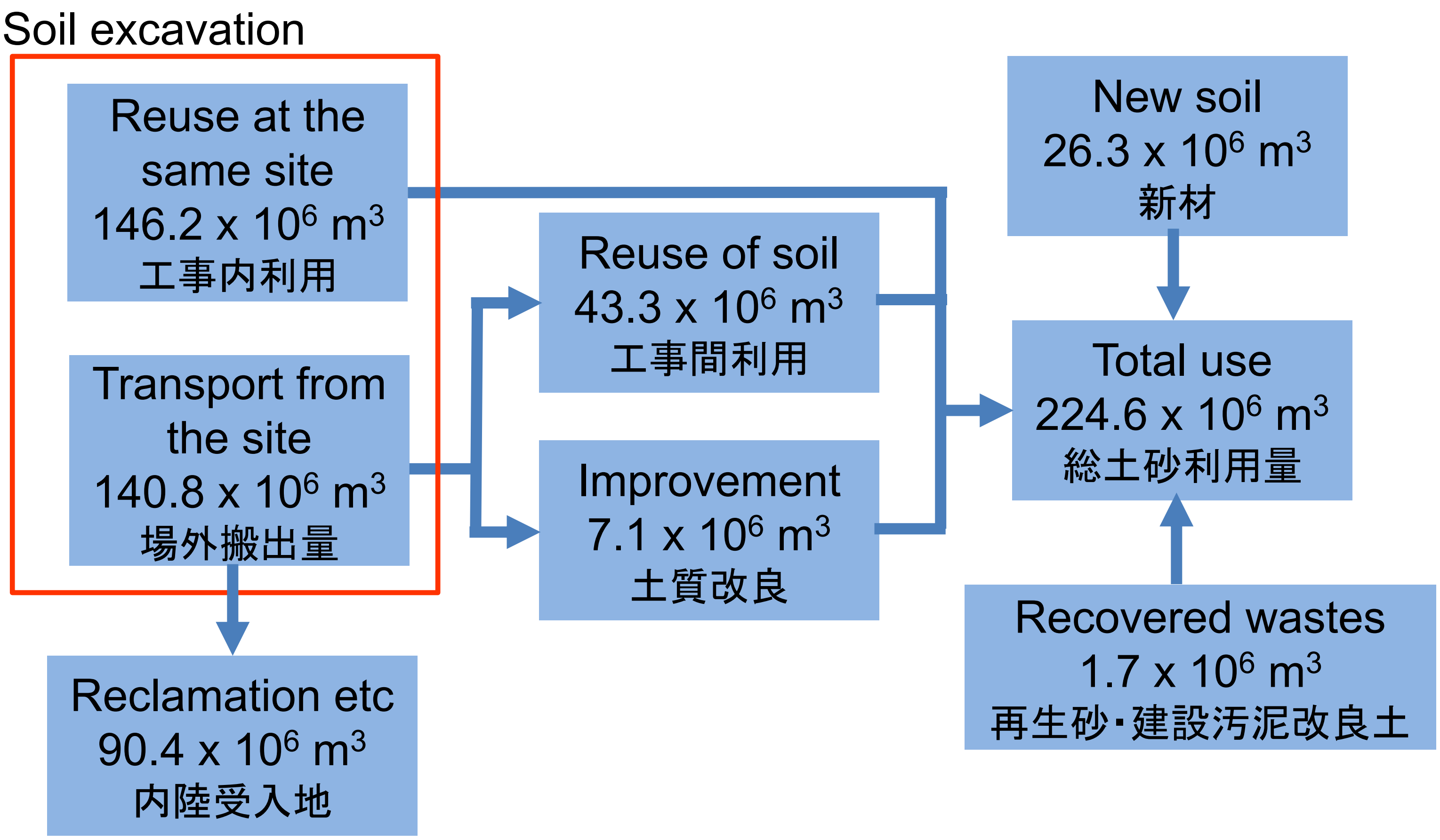
- ✓ Reduction of excavation （掘削土量の低減）
- ✓ Use of soils at the site of excavation （土砂発生現場での利用）

- ✓ Use of soils at different construction sites （発生現場以外での利用）
  - ✓ Standards of the Soils for Utilization
    (proposed 1994, fixed 2008, 発生土の土質区分基準)
  - ✓ Construction Material Recycling Act
    (2000, 建設リサイクル法)
  - ✓ Action Plan for Use of Excavated Surplus Soils
    (MLIT, 2003, 2008, & 2014, 建設リサイクル推進計画)
  - ✓ Soil Contamination Countermeasures Law
    (2002, revised 2010 & 2017, 土壌汚染対策法)



Status of surplus soils

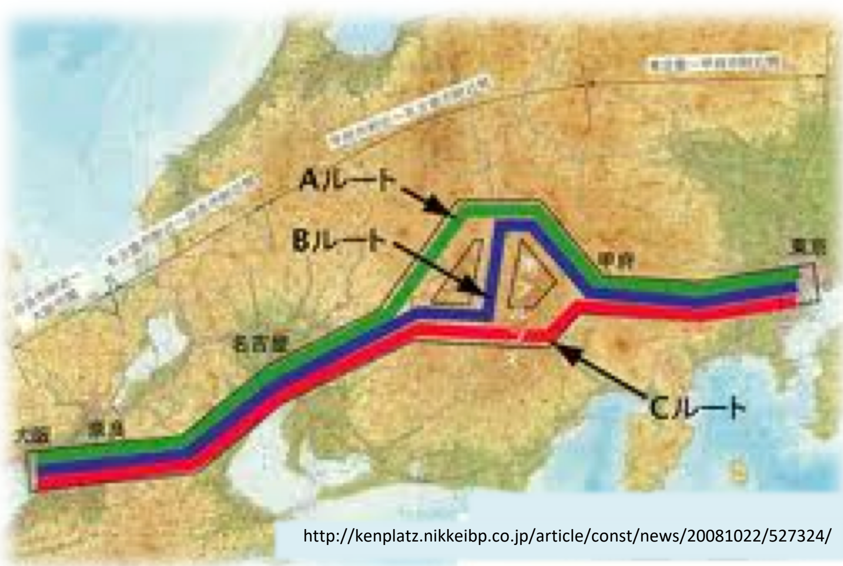
- ✓ Use of soils at the site of excavation
- ✓ Use of soils at different construction site without/with treatment
- ✓ Reclamation and landfill



Status of excavated soil in 2012（MLIT, 2014）

Several big projects in Japan

Route	Route	Completion scheduled	Total length	Tunnel
Chuo Shinkansen (Maglev) 中央新幹線	Shinagawa - Nagoya 品川～名古屋	2027	285.6 km	86% (246.6 km)
Hokkaido Shinkansen 北海道新幹線	Hakodate - Sapporo 新函館北斗～札幌	2031	211.5 km	76% (160.2 km)
Hokuriku Shinkansen 北陸新幹線	Kanazawa – Tsuruga 金沢～敦賀	2023	113 km	13 TNs incl. Shin-hokuriku TN (19.7 km)
Tokyo Outer Ring Road 東京外郭環状道路	東名JCT～大泉JCT	2020?	16 km	Entire route



Route for Chuo Shinkansen

Construction site for Tokyo Outer Ring Road

Natural contamination

- ✓ Soils and rocks containing arsenic, lead, etc. are widely distributed in Japan.
  - ✓ Marine clay and silt layers, mud stone…
  - ✓ Hydrothermally altered geology, metallic ore deposit or lode…
  - ✓ Old embankments, reclamation using dredged soils…
- ✓ Some soils generated through excavation works exceed regulatory standards for leaching of As, Pb, F, B, Se, etc.
  - ✓ Most of them only exceed slightly or 2-3 times higher than the standards. However, it will cost because entire layer will be a concern.

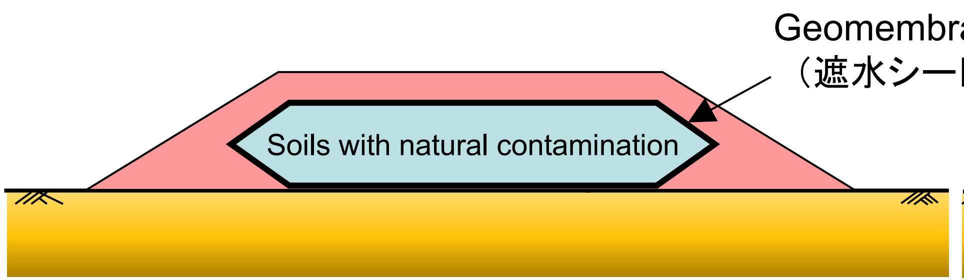

Tunnel excavation

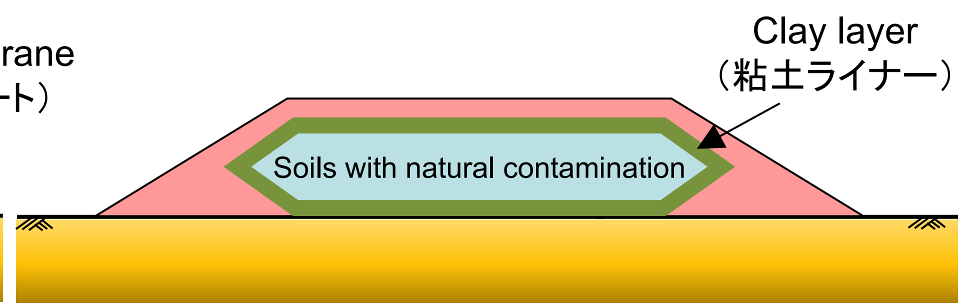

Embankment with geomembrane

Embankment construction using soils with natural contamination

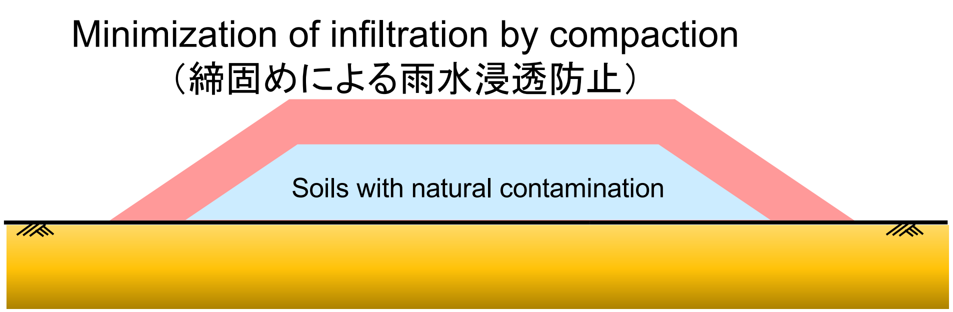
- ✓ Disposal of the soils at landfill sites is considered an option.
（処分場での土砂処分）
- ✓ Use of the soils in embankments with countermeasures is recommended.
（要対策土として盛土利用）

Immobilization method（不溶化）

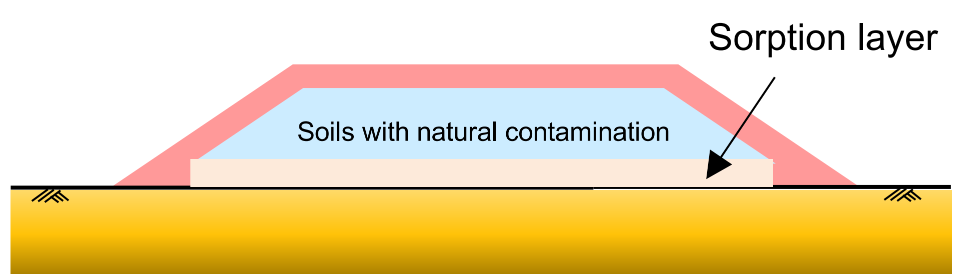




Embankment with containment system（封じ込め盛土）



Sufficient compaction（転圧による雨水浸透抑制）

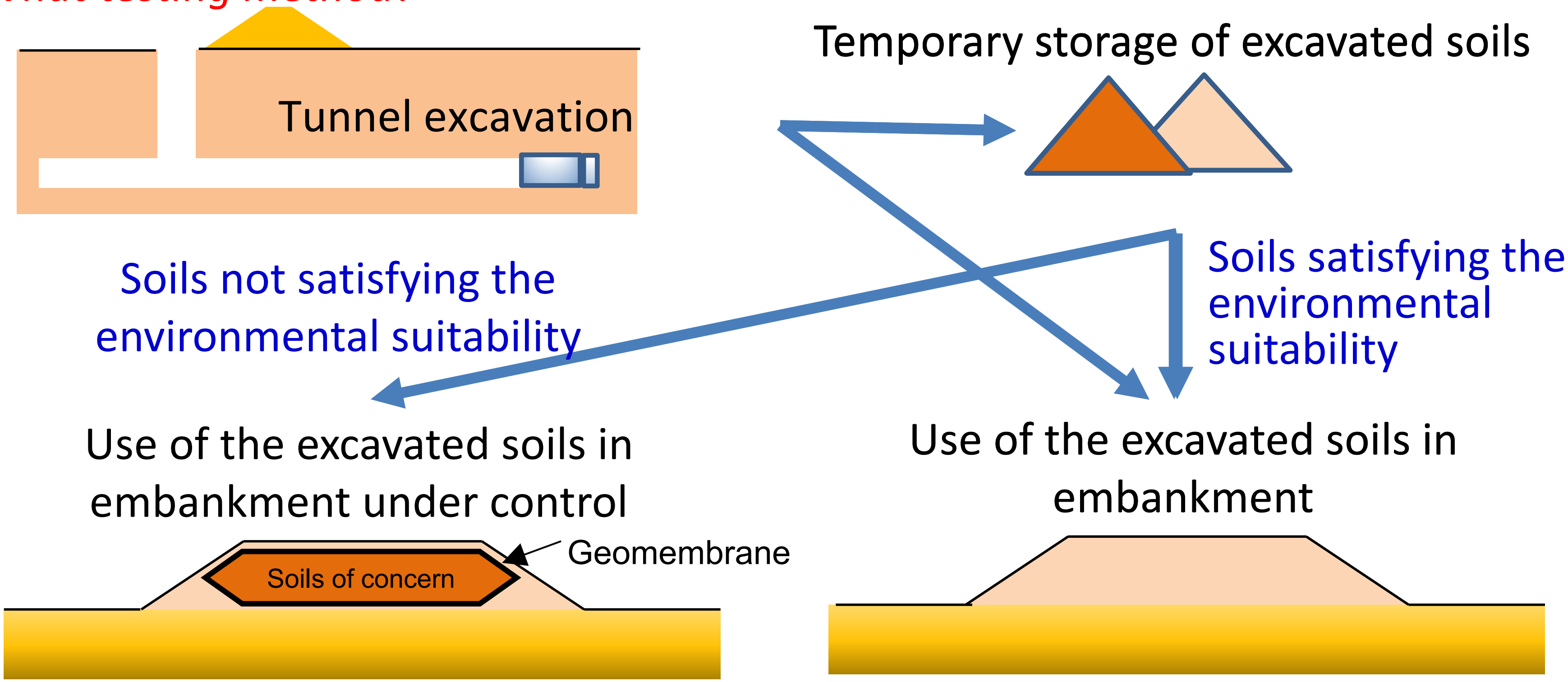


Sorption layer（吸着層工法）

Issues to be considered for excavated soils with natural contamination

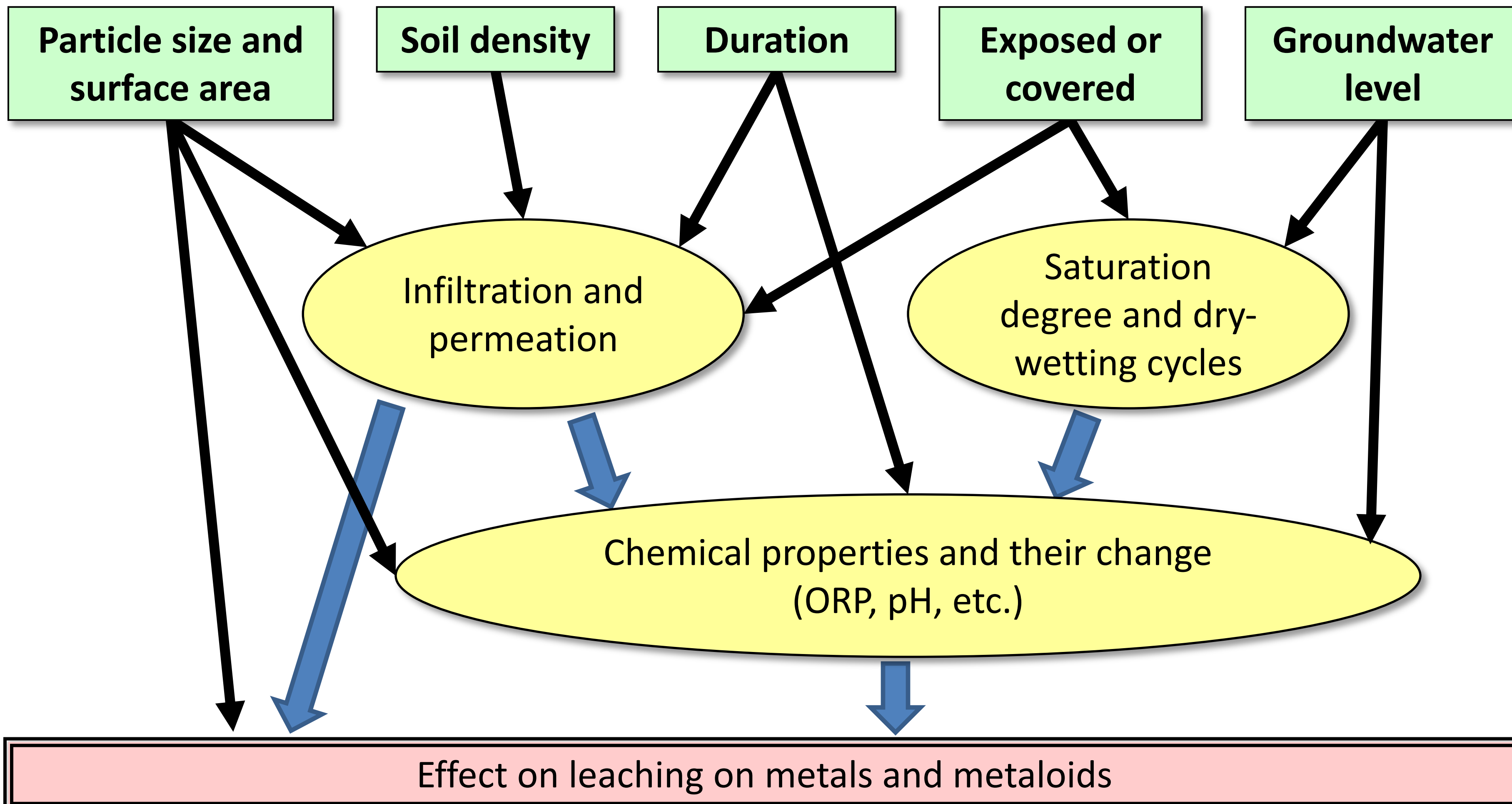
- ✓ *How should the environmental suitability be evaluated?*
- ✓ *What sampling method?*
- ✓ *What testing method?*

- ✓ *Do the temporary storage sites have sufficient capacity in terms of air apace and logistics, to store them during the test and then transport?*



- ✓ *Do the anticipated embankments have sufficient space to accept excavated soils?*
- ✓ *How much soils will not satisfy the environmental suitability?*
- ✓ *How should these embankments be managed technically and institutionally?*

Factors affecting leaching of metals & metalloids from soils/rocks



Concluding remarks

- Contributions of environmental geotechnics to the recovery from 2011 East Japan disaster have been conducted, particularly for characterization, standardization, and utilization of recovered soils. Use of RS contributed to disaster waste treatment completed in 3 years in Iwate and Miyagi prefectures. These achievements may be utilized for the recovery from future catastrophic disaster as well as the management of nuclide contaminated soils caused by Fukushima nuclear disaster.

  物性評価や標準化などの取組により、災害廃棄物からの分別土の利用が進み、災害廃棄物処理そのものにも貢献した。

- Natural contamination has been (and will be) a great concern. Appropriate method to evaluate environmental suitability of the soils/rocks to be used in embankments are required. Environmentally-safe and cost-effective countermeasures against the soils with natural contamination are also important considerations.

  自然由来の重金属等を含む土について、環境影響評価のための適切な方法ならびに合理的な対応法の確立が求められている。

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- ✓ National Institute for Environmental Studies 国立環境研究所
- ✓ Japanese Geotechnical Society 地盤工学会
  - ✓ Technical Committee on Geoenvironmental Engineering
  - ✓ Committee for Recommendation on Soil Utilization in Disaster Recovery
  - ✓ Committee for Review on Soil-Radioactive Cesium Interactions
  - ✓ JGS Officers
- ✓ Dr Toru Inui, Dr Atsushi Takai, & other members at Kyoto Univ. 京都大学

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- ✓ 嘉門雅史・勝見　武（監修）・独立行政法人土木研究所・一般財団法人土木研究センター地盤汚染対応技術検討委員会（編著）（2015）：建設工事で発生する自然由来重金属等含有土対応ハンドブック，大成出版社.