KUALA LUMPUR 2012 WORLD GAS CONFERENCE

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THE JAPAN GAS ASSOCIATION

Effects of the Large-scale Earthquake and Tsunami on an LNG Receiving Terminal

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6th JUN 2012

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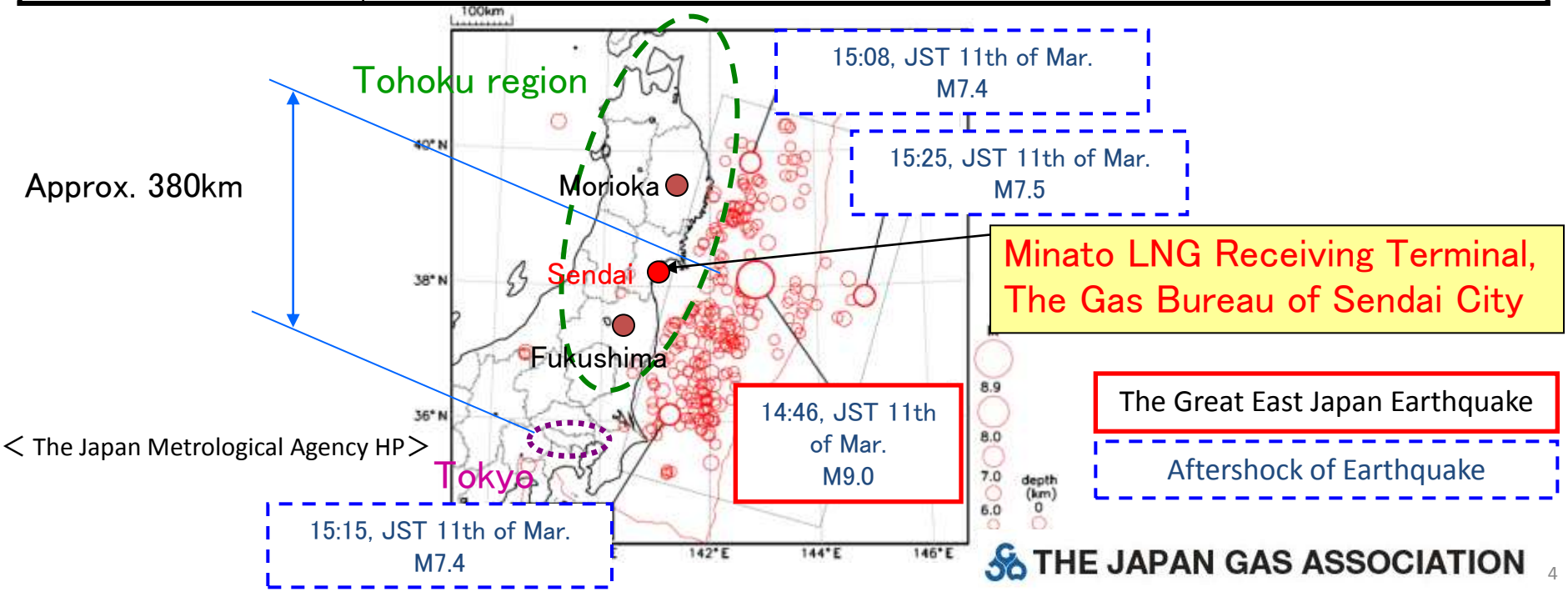
Focus

- Damage to an LNG receiving terminal
- Procedure of emergency recovery
- Measures for restoration

Contents

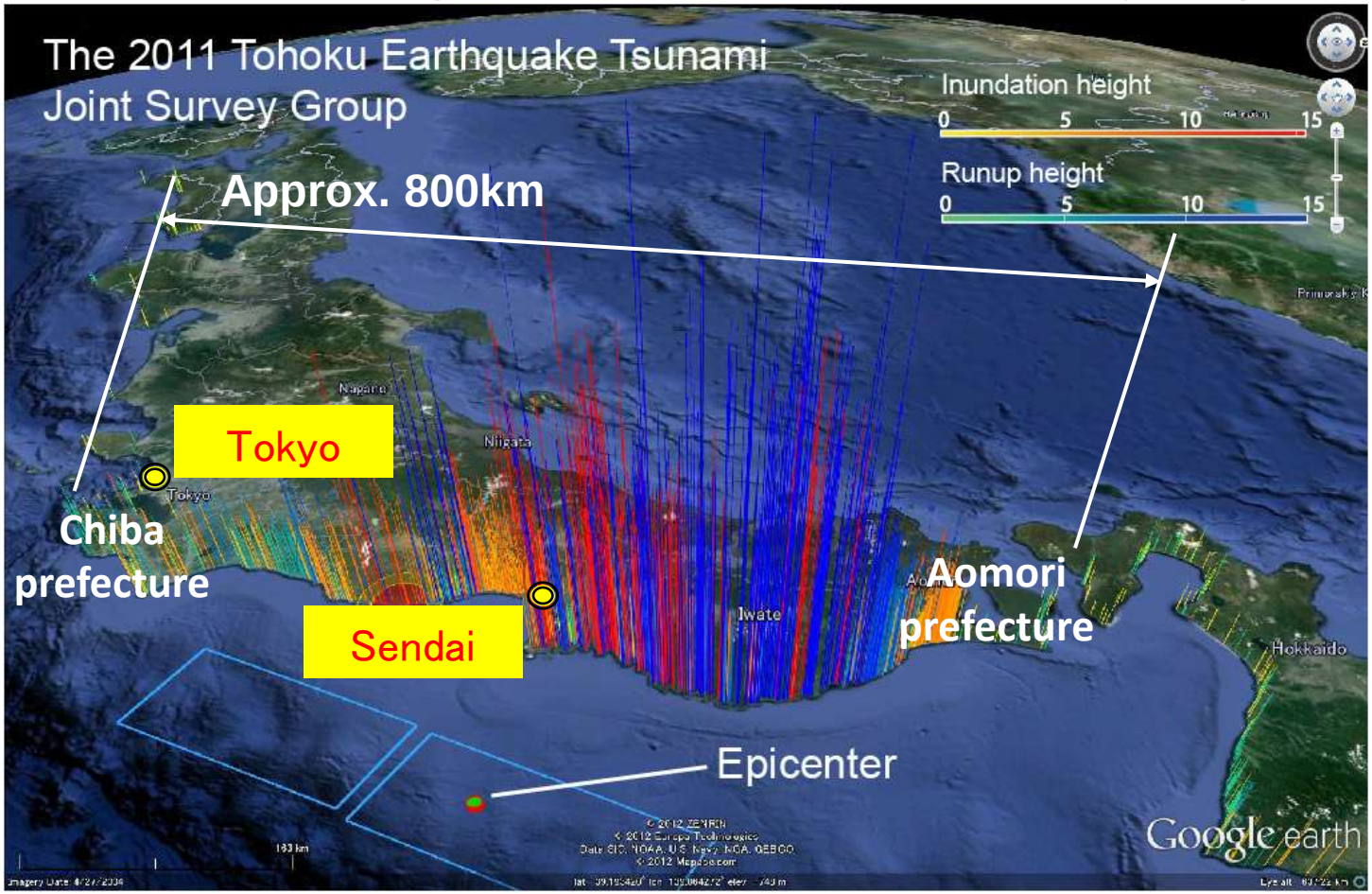
1-1. Summary of " The Great East Japan Earthquake"

Date and Time	14:46, JST 11th of March, 2011
Magnitude	Mw 9.0
Hypocenter	130km ESE off coast, Depth 24km
Characteristic	・The biggest earthquake in the modern history of Japan. ・The duration of the earthquake was long as 170 seconds. ・The seismic area was 200km in width and 500km in length.



1-2. Reported Height of Tsunami

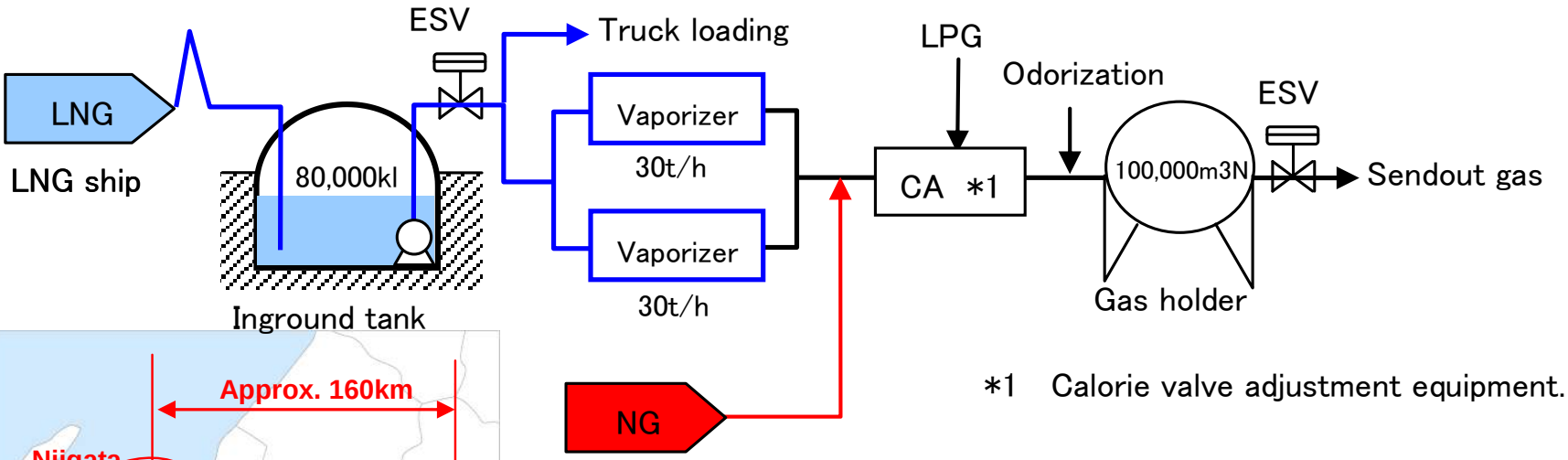
- The height of the tsunami was unprecedented in modern times.
- The maximum flood height was 15 meters with a run up height of 40 meters.



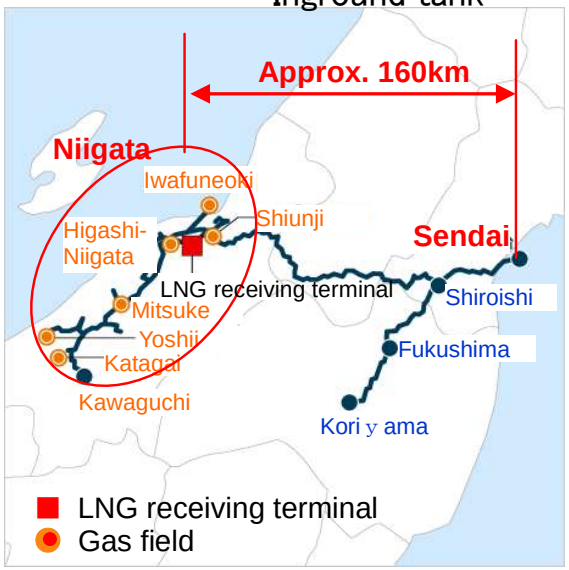
Contents

2-1. Outline of the Minato LNG Receiving Terminal, The Gas Bureau of Sendai City

■ The gas supply process comprises an LNG re-gasification system and a natural gas high-pressure pipeline system from inland.



*1 Calorie valve adjustment equipment.



High-pressure natural gas pipeline

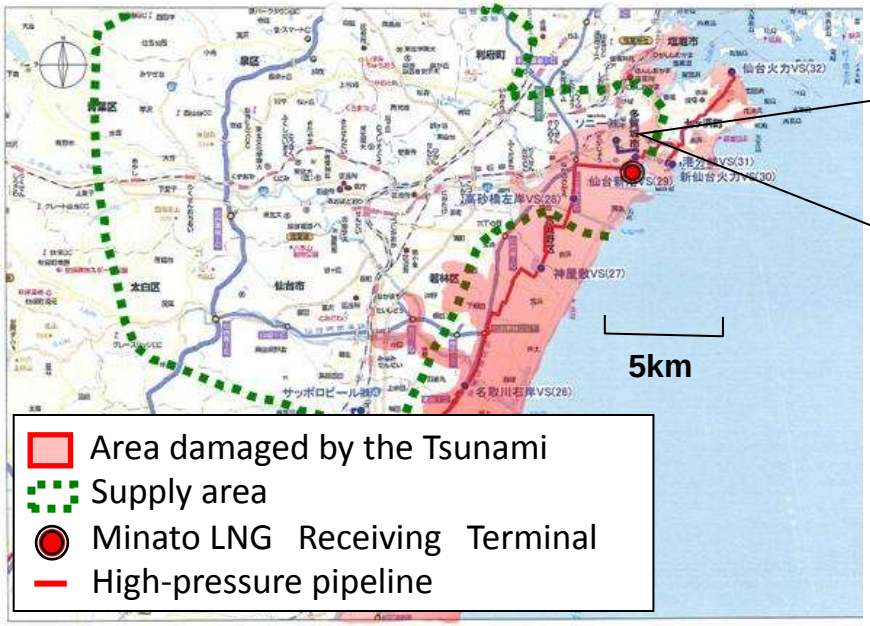
＜Ratio of gas sendout volume＞

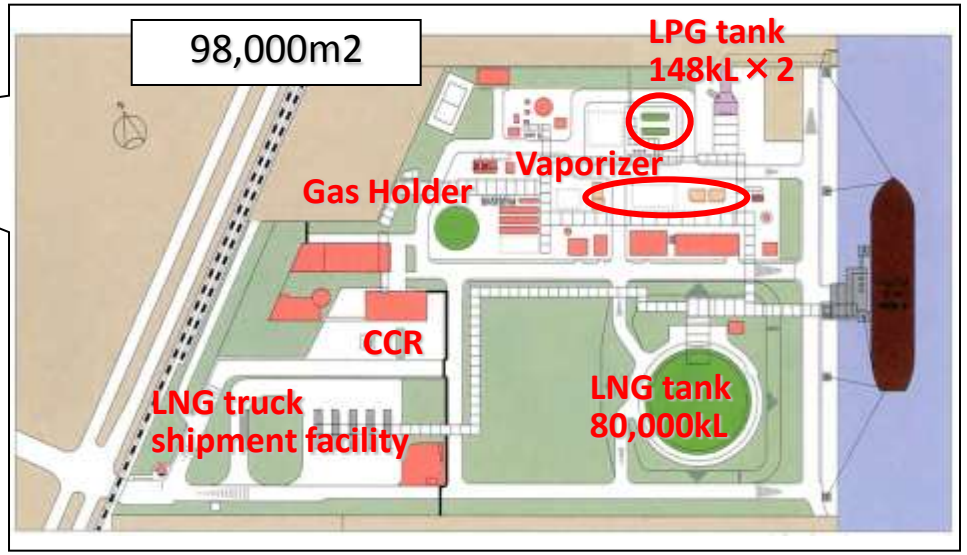
■ LNG re-gasification system : 7

■ NG high-pressure system : 3

2-2. Damage to the LNG Receiving Terminal

- Earthquake caused almost no damage.
- Tsunami (maximum 4 meters height from the ground) struck 1 hour after the earthquake.
- The operationability of LNG terminal was lost , however there was no loss of life , LNG leaks , or any other secondary disasters.





2-2. Damage to the LNG Receiving Terminal

video

2-3. Damage by the Tsunami

- All areas except LNG tank area were flooded.
- Soil of 2 meters from the ground was scoured.

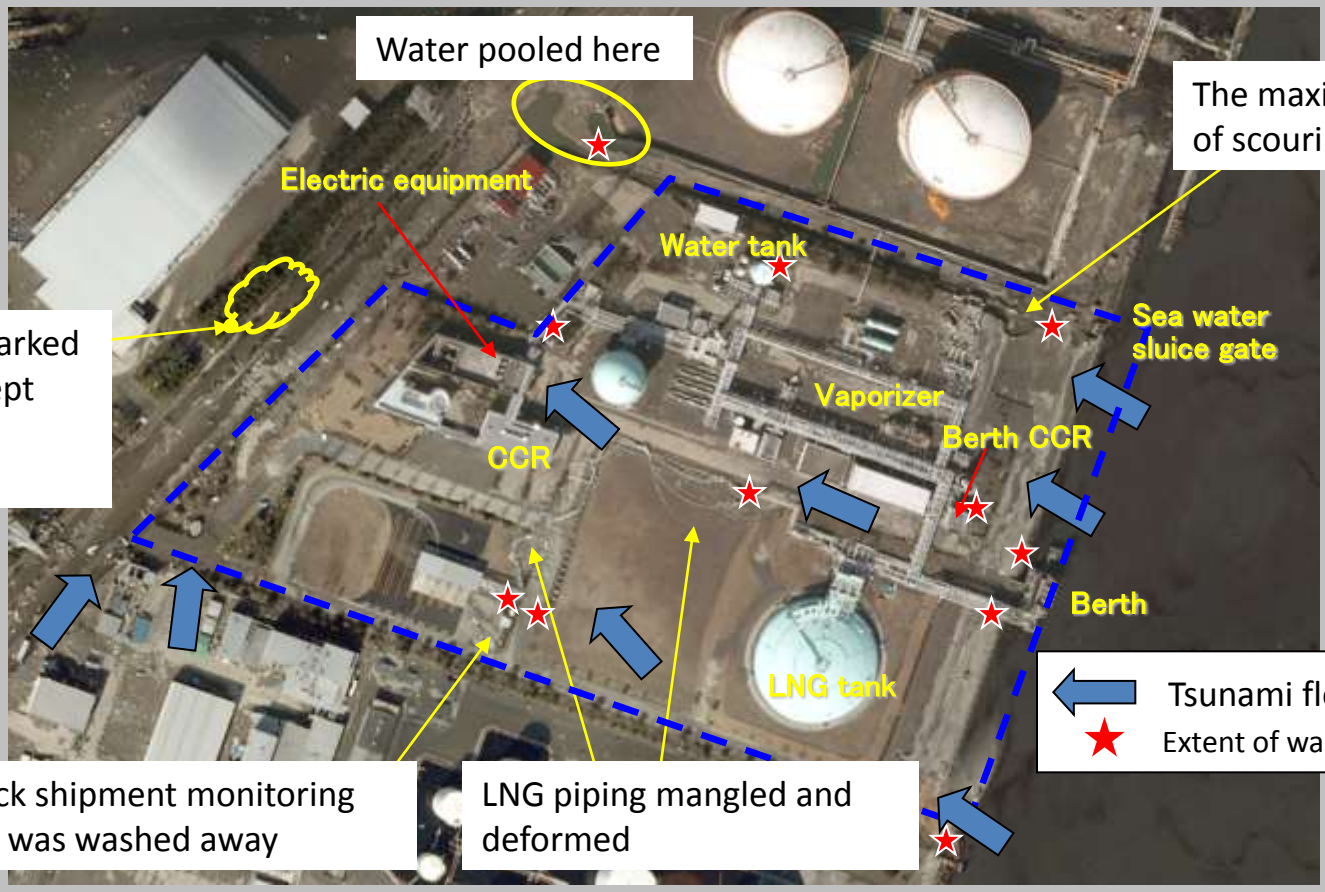


Photo : Geographical Survey Institute on the next day of the earthquake

2-3. Damage by the Tsunami –Characteristics of Damage by the Tsunami

Near the sea water sluice gate

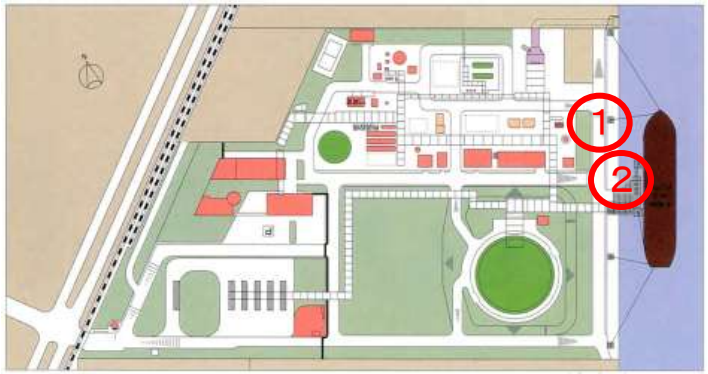
Flat slab foundation structures

Water tank (pile foundation)

Damage of washed away areas

- The area where flow was concentrated was seriously damaged.
- Drifting objects didn't cause serious damage.
- The slab foundation was damaged.
- Equipment with pile foundations were not seriously damaged.
- Erosion was quick to occur around unpaved locations.

2-4. Damage of equipment –LNG receiving facilities—



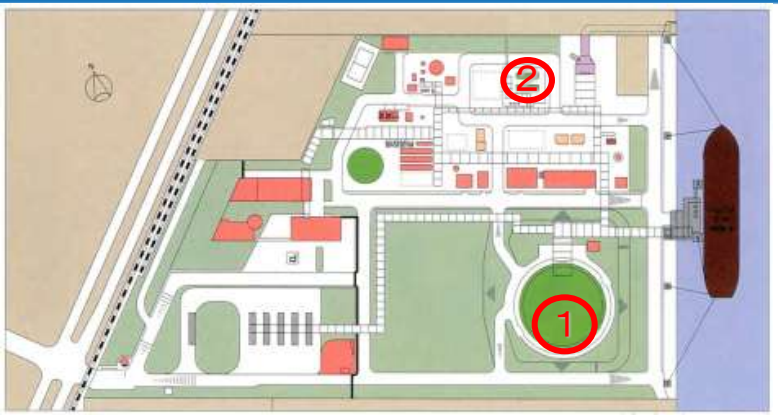
◆1. Receiving Equipment

Only some scouring on the surface of the ground which did not effect it's operationability.

◆ 2. Bank

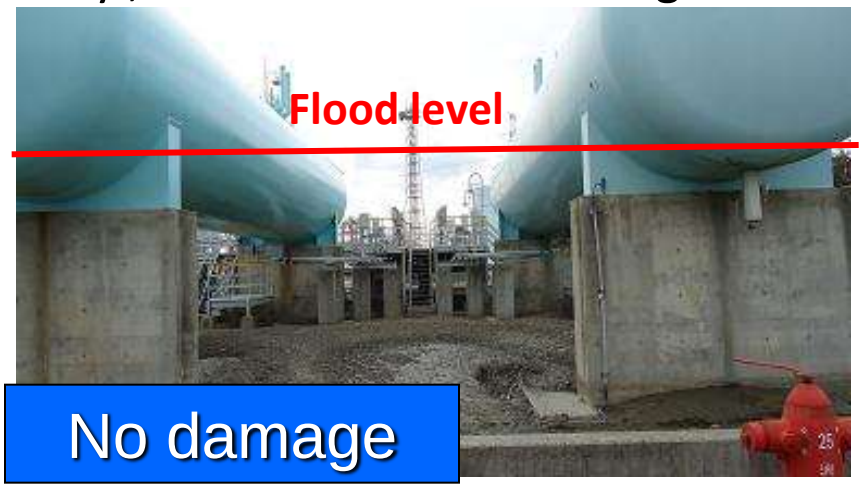
There was some partial scouring on the surface. However, there was no damage to the sheet-pile and the bank remained intact.

2-4. Damage of equipment –LNG & LPG storage tanks–



◆2. LPG storage tank

A part of it was flooded , some of the soil around the foundation was washed away , but there was no damage.



◆ 1. LNG inground tank

Luckily being on the top of a 4 meter banking hill spared it from being flooded.

2-4. Damage of equipment –LNG piping and piping framework—

Damage

◆1. Shallow foundation of piping framework

- Framework collapsed due to being washed away around the foundation which were quite shallow.
- Although the piping was deformed there were no LNG leaks.

2-4. Damage of equipment –LNG piping and piping framework—

◆ 2. Loosely fitted piping allowed floating

- End of branch piping for future additional piping was not completely fixed to any framework and as such suffered severe deformation.

- Emergency shut down was carried out quickly, and there were no LNG leaks.

2-4. Damage of equipment –Piping and piping framework—

◆ 1，2 The piping frame of the pile foundation and underground piping

Although these were suffered severe water flooding, there was no damage and the operationability was maintained.

◆ 1. Gas distribution pipe

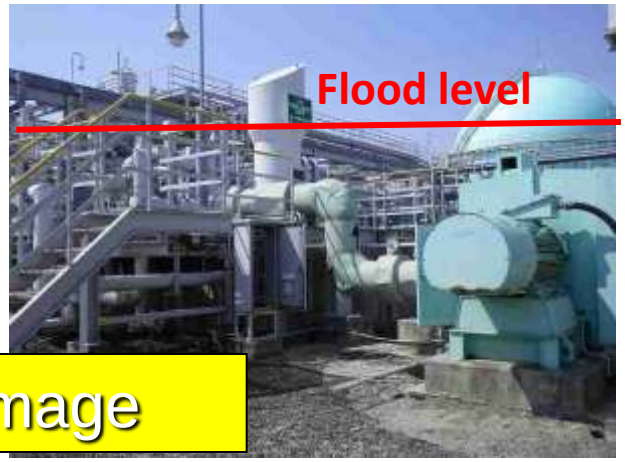
◆ 2. Piping over pile foundation

No damage

2-4. Damage of equipment –LNG Vaporizer—

◆2. Submerged combustion vaporizer

Control board and combustion air blower were flooded and the operationability was lost.



Damage

◆1. Open rack vaporizer

It was not damaged.

2-4. Damage of equipment –Electric/Control System Equipment—

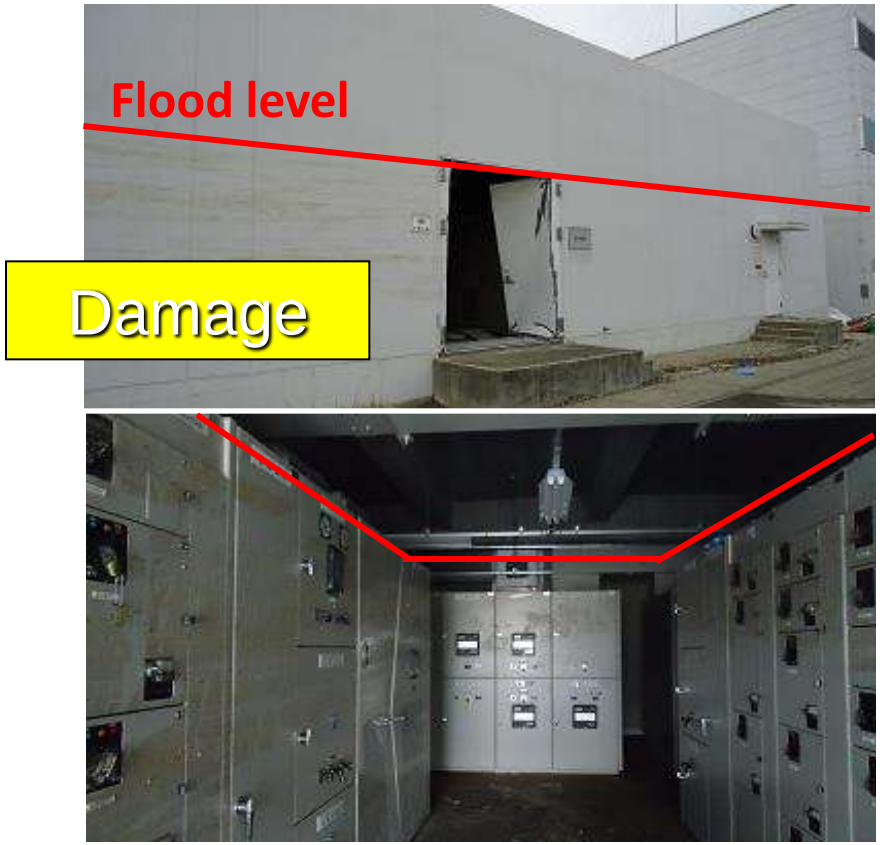
◆2. Power receiving equipment

Outside installation was flooded and equipment failed.

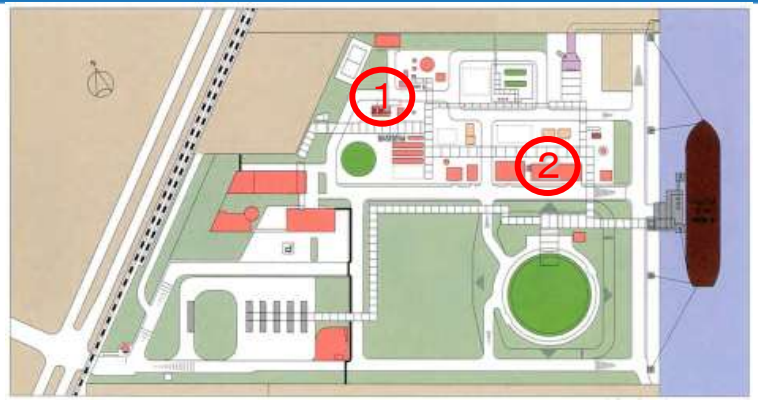
◆ 1. Substation equipment

Tsunami damaged non watertight doors allowing internal flooding.

The equipment operations failed.



2-4. Damage of equipment –other equipment—



◆2. BOG compressor

It was installed on the second floor and not damaged.

◆1. Odorization equipment

It had highly airtight doors with no aperture, no flooding occurred.

2-4. Damage of equipment –buildings—

◆1. Berth control center building

The wall and windows at the first floor were damaged.

◆2. LNG truck loading building

A lightweight building was swept away.

2-5. Summary of damage to the LNG Receiving Terminal

- The main cause of the damage to the facilities was the tsunami.

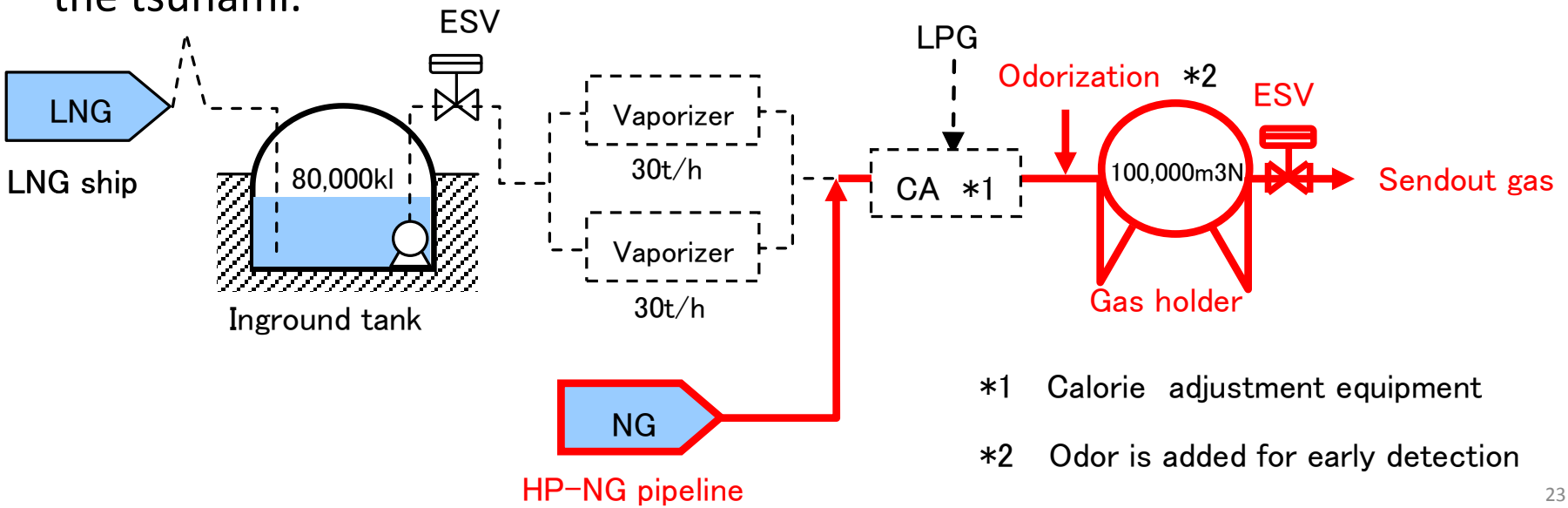
- Gas outage due to the shut down of the Electric and Control system equipment.

- There was no loss of life , LNG leaks , or any other secondary disasters.

Contents

3. Procedure of Emergency Recovery

- The complete recovery of the plant was assumed to take a substantial amount of time.
- A high-pressure natural gas pipeline from another terminal was utilized for the early restoration (emergency restoration) of the gas supply.
- Safety measures and the implementation of emergency measures for the minimum necessary requirements to monitor the plant.
- Resumption of the gas supply took place 12 days after the earthquake and the tsunami.



Contents

4-1. Measures for Restoration

-Basic Approach to Tsunami Countermeasures for restoration -

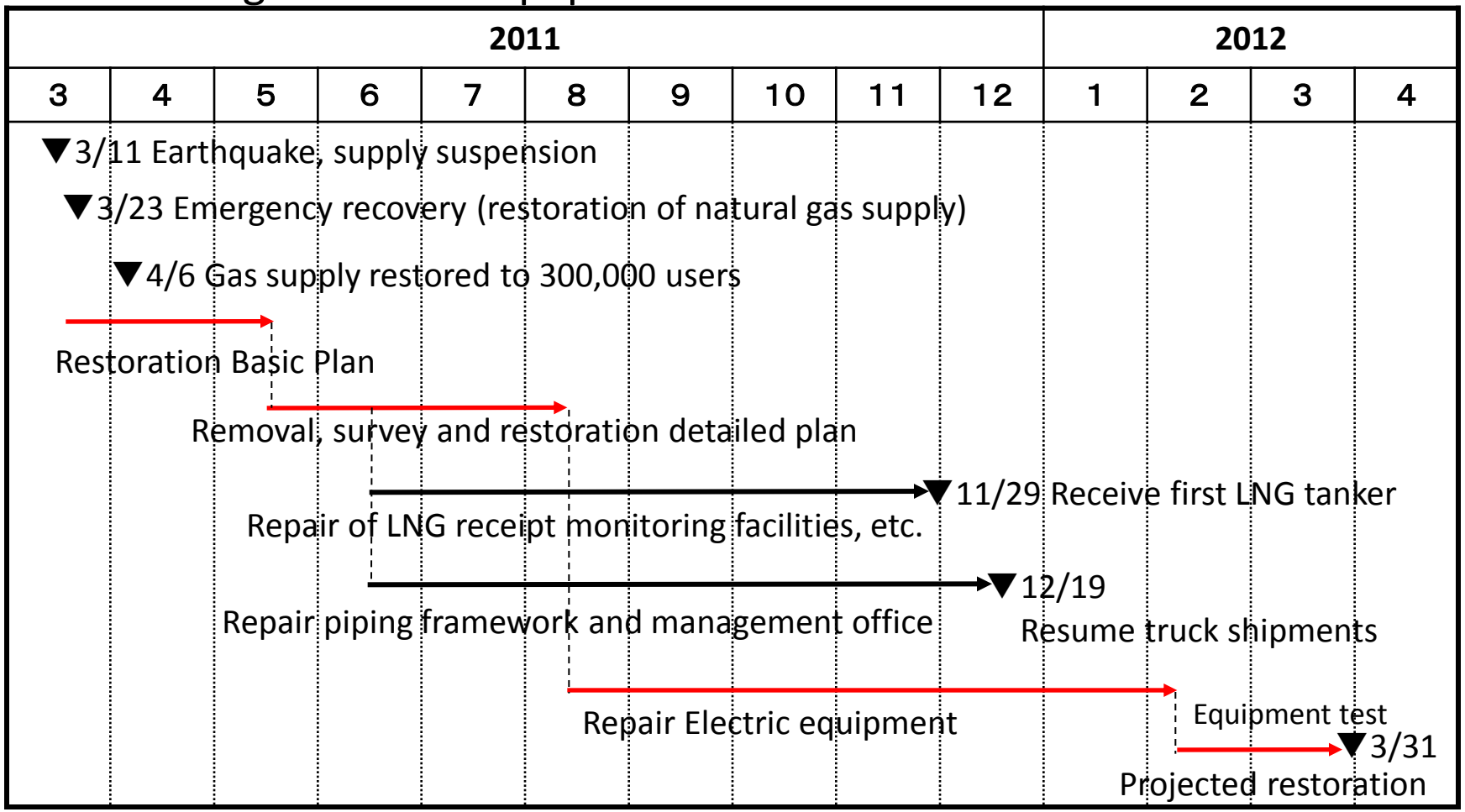
1) Take into account the actual tsunami height for design

2) Arrange certain safety measures to protect human life

3) Improve resistance to tsunami on important facilities that impact early restoration

4-2. Restoration Schedule

■ It has taken a total of 12 months from the earthquake for full recovery of LNG re-gasification equipment.



4-3. Measures to improve facilities

-Preventing Piping and Piping Framework from being damaged-

■ The foundation of piping framework was changed from slab type to pile type.

a slab foundation

a pile foundation

Secure pipes to prevent floating

4-3. Measures to improve facilities -Improved Building Flood Prevention-

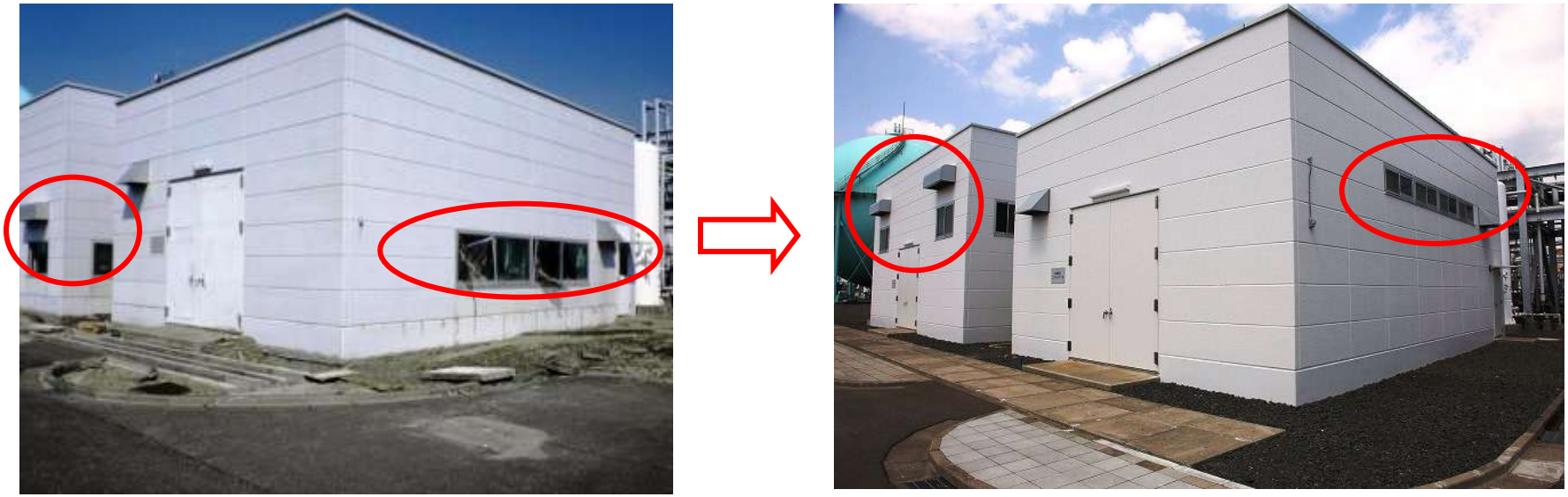
■ Replacing doors of important buildings with watertight (airtight) doors like those in the odorization building.

odorization room

Watertight door

4-3. Measures to improve facilities -Improved Building Flood Prevention-

■ Apertures of the building were moved to higher locations.



The Air compressor building

■ The LNG receipt and truck loading monitoring facilities, which had been on the first floor and suffered damage, were relocated to the second floor.

Contents

5. Conclusion

Damage Situation

- Earthquake and Tsunami scale were the largest in modern times.
- Gas outage due to serious damage to Electric/control system and other equipment.

Observation

- The earthquake barely affected the plant's operationability.
- The main cause of damage to the facilities was the Tsunami.

Countermeasure

- It is difficult to completely protect facilities from tsunamis of this size.
- To achieve early recovery, it is necessary to improve the tsunami resistance of equipment that takes a long time to repair.
- For example, making buildings more water-tight, raising equipment above expected flood levels and changing to pile foundations.

Our report should provide a useful reference for future tsunami countermeasures at LNG terminals worldwide.

Thank you for your attention