

Countermeasures of Hamaoka NPS Reflecting from the Great East Japan Earthquake Disaster



July 2011 Chubu Electric Power Co., INC.
中部電力株式会社

- It is the announcement that we decided to implement the countermeasures for tsunami in Hamaoka Nuclear Power Station by reflecting knowledge and experiences gained through the accident of Fukushima Dai-ichi Nuclear Power Station of TEPCO caused by the Tohoku-District off the Pacific Ocean Earthquake.
- The purpose of our countermeasures for tsunami is to enhance further for the safety of Hamaoka NPS while we seriously respond to the upsurge of social anxiety regarding nuclear power generation.
- We have confirmed the safety of the plant against tsunami with considering the past tsunami which strongly affected to the site such as Ansei-Tokai and Hoei earthquake. Also, we already completed Emergency Safety Measures that requested by the regulators.

Outline of Countermeasures for Tsunami

- ◆ Our countermeasures consist of three steps for the protection. First is to prevent flooding inside the power station site; second is to prevent flooding inside the building; and the last one is to ensure cooling function.
- ◆ Specifically, the measures ensure to lead to cold shut-down with safety manner under the assumption of both Station Black Out (SBO) and Loss of Sea Water Cooling Function that occurred at the Fukushima-Dai-ichi, even after the installation of the sea wall and other protection measures against flooding.
- ◆ As a result, **even in the case of severe situation such as loss of plural functions of the protection system, our measures satisfy the safety based on the idea viewing from redundancy and diversity.**

Ensuring Safety

Prevent Flooding Inside The Power Station Site

Prevent Flooding 1

- ◆ Install the sea wall with T.P. +18m and prevent flooding inside the power station site

Prevent Flooding Inside The Building

Prevent Flooding 2

- ◆ Prevent Flooding by Tsunami that exceeds over the sea wall

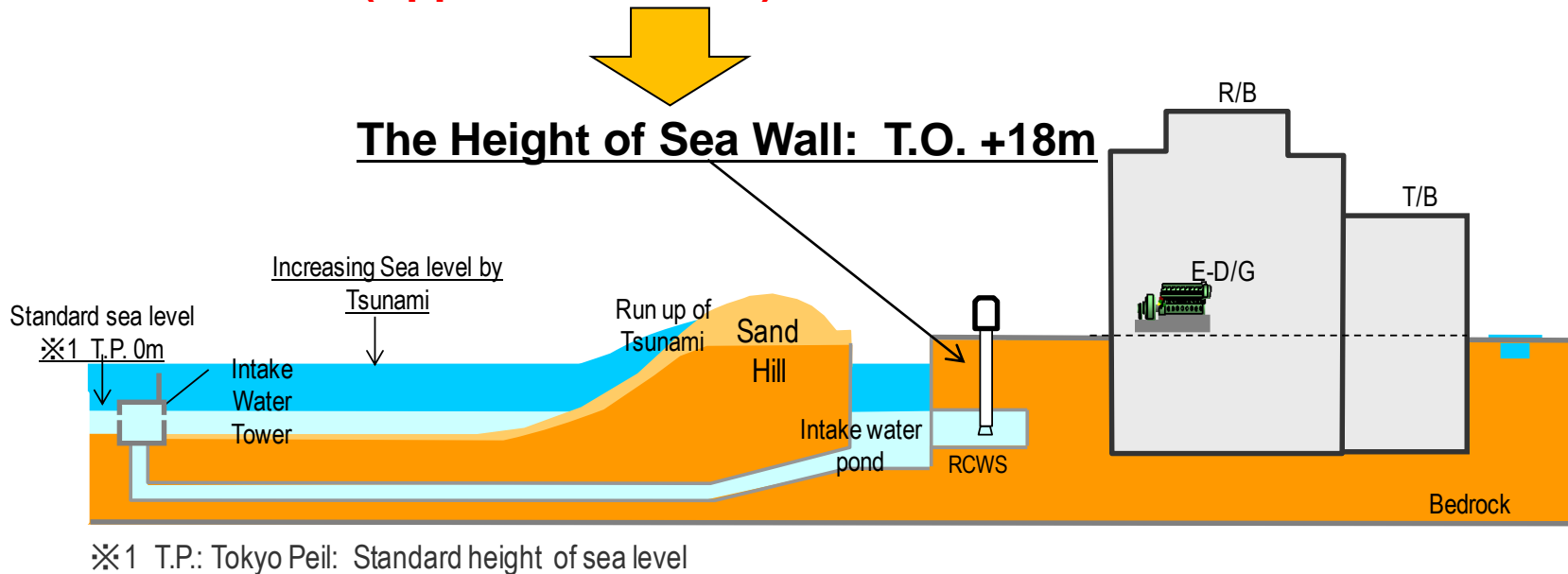
Ensure Cooling Function

Ensure Cooling Function

- ◆ Assuming the event occurred at Fukushima such as SBO and Loss of Sea Water Cooling Function, we will ensure cooling system to achieve cold shutdown.

Outline of Countermeasures for Tsunami

- ◆ Regarding the sea wall suppose to install the seaside of the power station, its height is decided to reflect run up height of tsunami, experienced at Fukushima Dai-ichi (Approx. T.P. +15m).

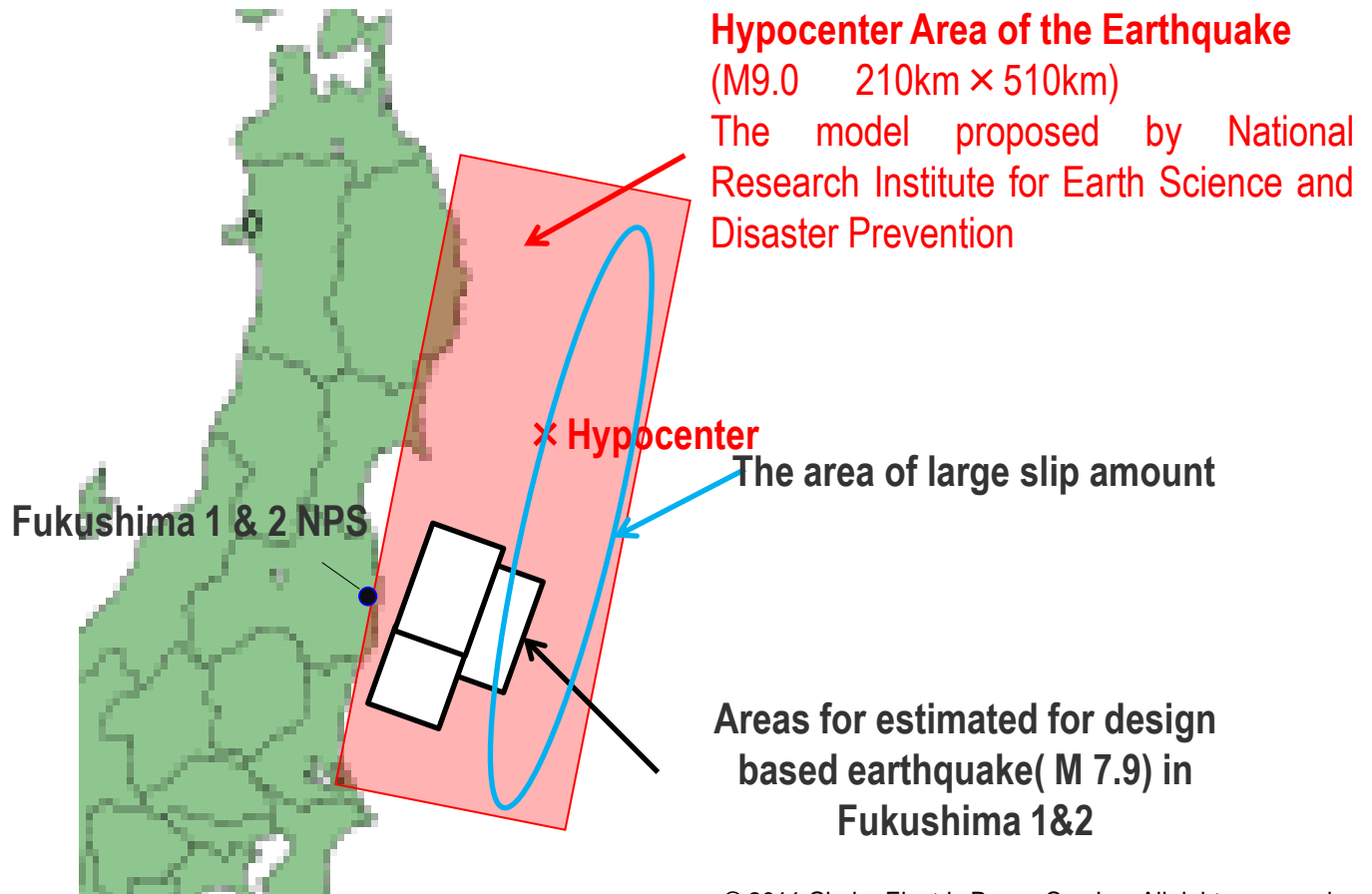


- ◆ The run up height of tsunami at the Hamaoka NPS is estimated about T.P. +8m with considering the tsunami associated with triple interlocked earthquake of Tokai, Tonakkai, and Nankai
- ◆ As a result of estimation considering virtual tsunami of Magnitude 9 class earthquake, same scale of the Tohoku-District off the Pacific Ocean Earthquake, we computed T.P. +10 m of tsunami height.

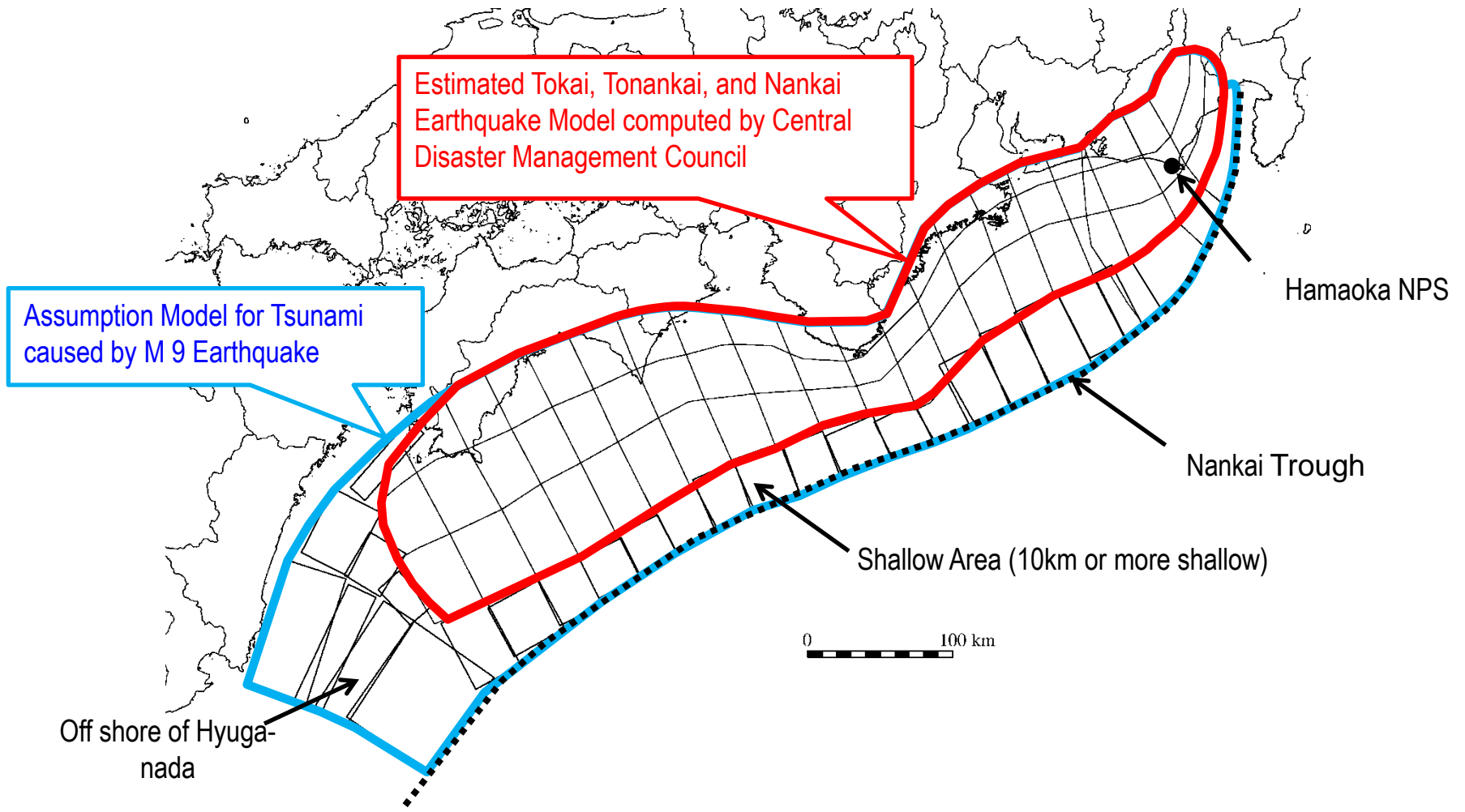
- ◆ We will take appropriate measures in quick manner by reflecting updated knowledge from the investigation of the accident at Fukushima Dai-ichi NPS and study results from the Central of Disaster Management Council.
- ◆ Moreover, based on the knowledge from the accident, we will review and reinforce our disaster protection management.

In the earthquake, both normal interlock type earthquake and tsunami earthquake without big quake simultaneously.

- (1) By having interlocked in the very wide range from offshore of Sanriku to Ibaragi, the magnitude of an earthquake becomes large to 9.0,
- (2) Big slippage at shallow portion of the plate boundary generated extra-high tsunami.

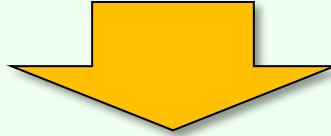


M 9 Earthquake Model Applied to Hamaoka NPS



Result of Computing for virtual M9 Class Tsunami

◆ Run up height of the virtual tsunami is about T.P. +10m



◆ The height does not exceed the natural embankment of sand hill in front of the power station.

◆ Regarding Seismic Safety

① Hamaoka NPS completed construction work to extend safety margin of seismic resistance by targeting 1000 gal of earthquake motion. Also, we estimate triple interlocked earthquake of Tokai, Tonankai, and Nankai as for Standard Earthquake Motion evaluation

② The influence on the site of power station is small; therefore, it does not effect on safety among the earthquake of M9, the far region of Hyuga-nada, and tsunami earthquake without short cycle motion that occurred shallow portion

◆ We will take appropriate measures in quick manner by reflecting updated knowledge from the Central of Disaster Management Council.

Countermeasures for Tsunami (3 Steps)

Ideas for Protection

- ◆ Basic idea of ensuring the safety of NPP is **Shut-down, cooling, and containment.**
- ◆ In the case of Fukushima Dai-ichi, the plant **lost the AC power**, what is called SBO.
- ◆ In addition, the plant **lost Sea Water Cooling system.**
- ◆ As a result, the **plant lost cooling function** and led to the accident.
- ◆ Regarding countermeasures for tsunami, we will carry out to prevent flooding inside the power station site, prevent flooding inside the building, and ensuring cooling function.

Ensuring Safety

Prevent Flooding Inside The Power Station Site

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Ensure Cooling Function

- ◆ Assuming the event occurred at Fukushima such as SBO and Loss of Sea Water Cooling Function, we will ensure cooling system to achieve cold shutdown.

Prevent Flooding Inside The Power Station Site

Prevention of Flooding (1)

Prevention of Flooding

◆ Countermeasure is roughly divided into 2 parts

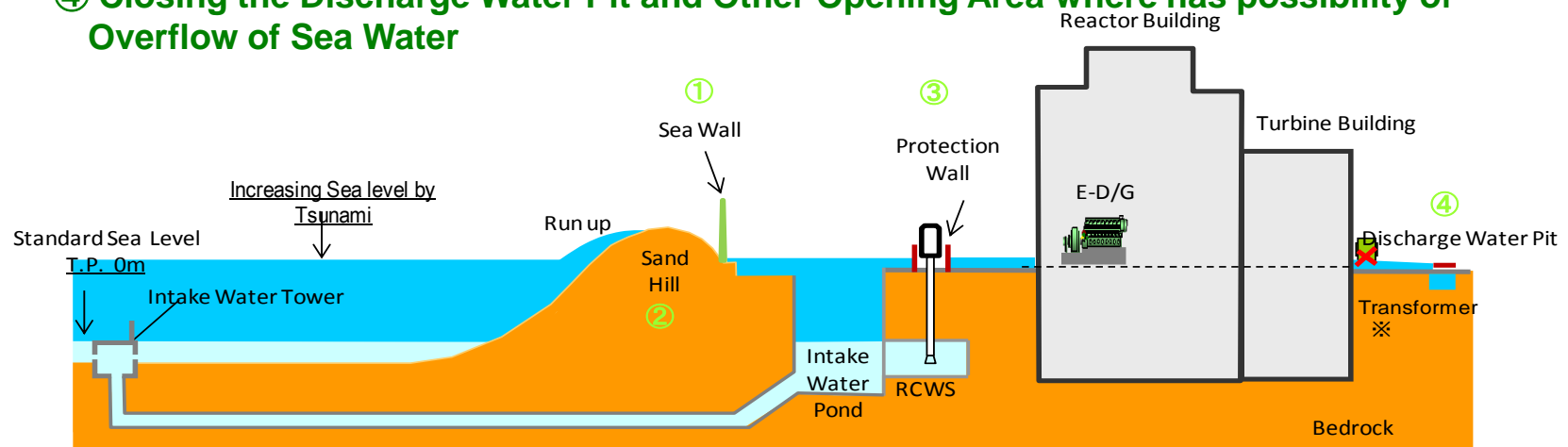
- (1) To protect flooding by direct intrusion of tsunami inside the power station site
- (2) To prevent flooding by overflow from intake water pond because of increasing the level of sea water

(1) To protect flooding by direct intrusion of tsunami

- ① Installing the Sea Wall with T.P. +18 m height to the Sea Side of the Power Station
- ② Reinforcement of the Sand Hill in front by Banking

(2) To prevent flooding by overflow

- ③ Installing the Protection Wall, which has 1.5 m height, surrounding the Sea pump Area
- ④ Closing the Discharge Water Pit and Other Opening Area where has possibility of Overflow of Sea Water



※ We do not expect of restoration of the Transformers because they are not available in the case of sea water intrusion by Tsunami.

Prevention of Flooding (1)

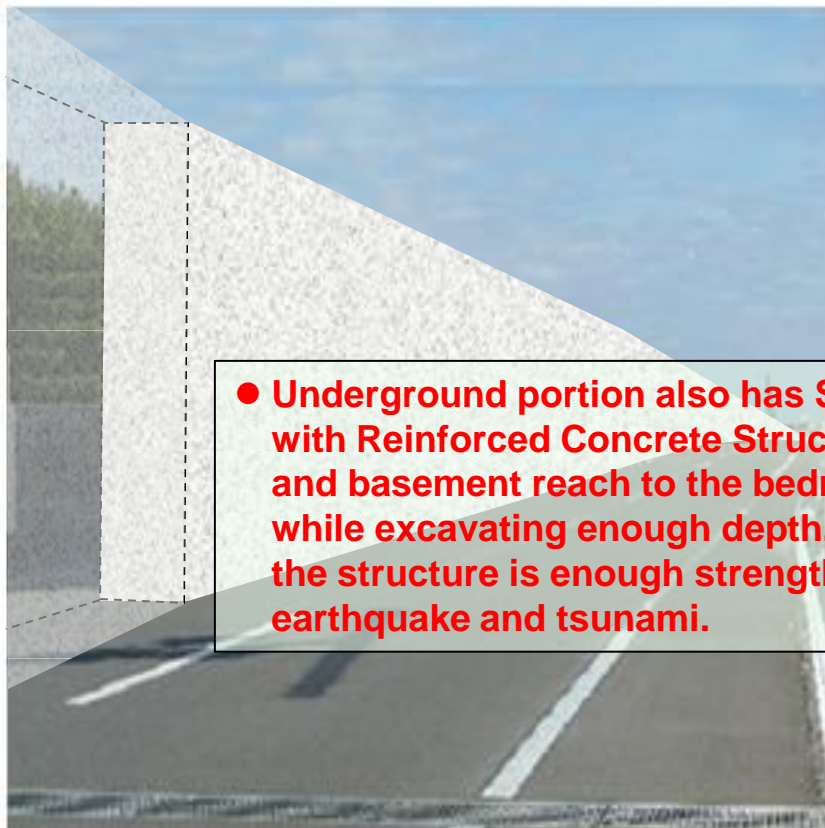
Structure of the Sea Wall

■ Height: T.P. +18m

The height of the sea wall is 18 m from the sea level with referring the experience of Fukushima Dai-ichi where run up height of tsunami was T.P. +15 m, and height of existing sand hill in front of Hamaoka NPS (T.P. +10-15m)

■ Wall Structure : L shape Retaining Wall Steel and Complex structure of Steel with Reinforced Concrete Structure

■ Basement Structure : Continuous wall under the ground with reinforced concrete structure supported by bedrock.



- **Underground portion also has Steel with Reinforced Concrete Structure and basement reach to the bedrock while excavating enough depth. So far, the structure is enough strength to the earthquake and tsunami.**

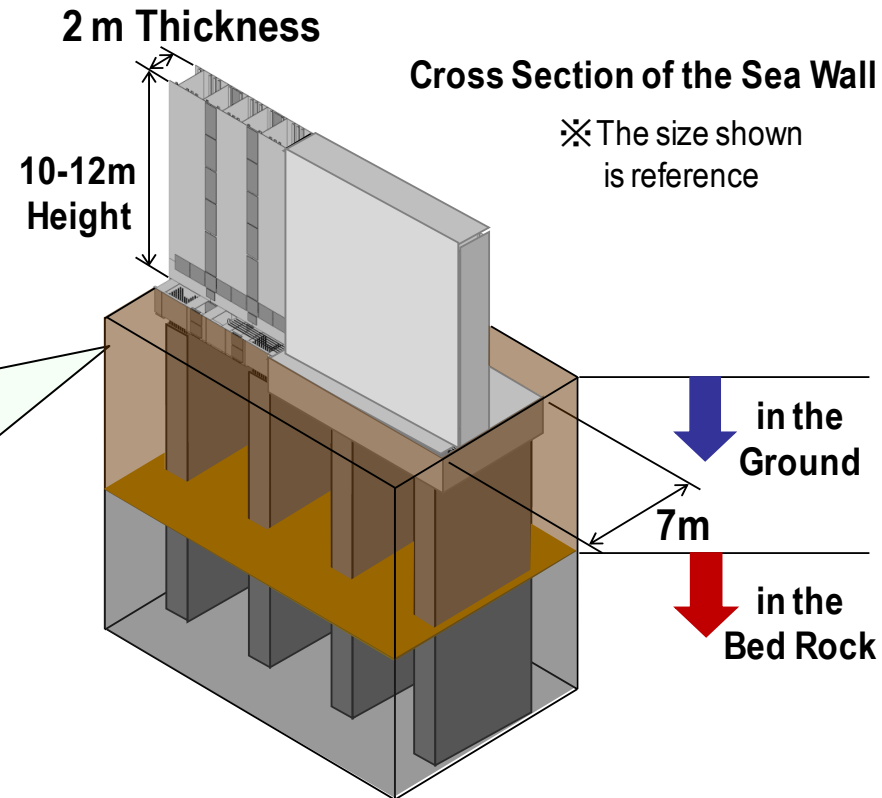
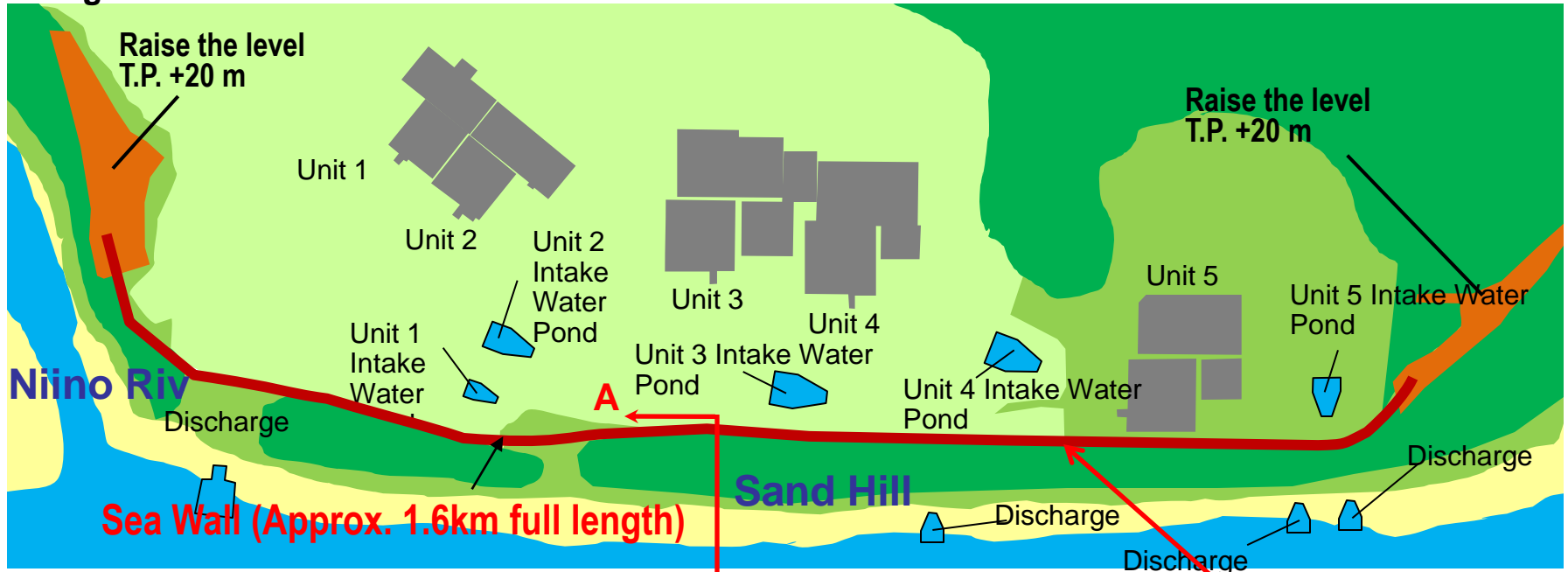
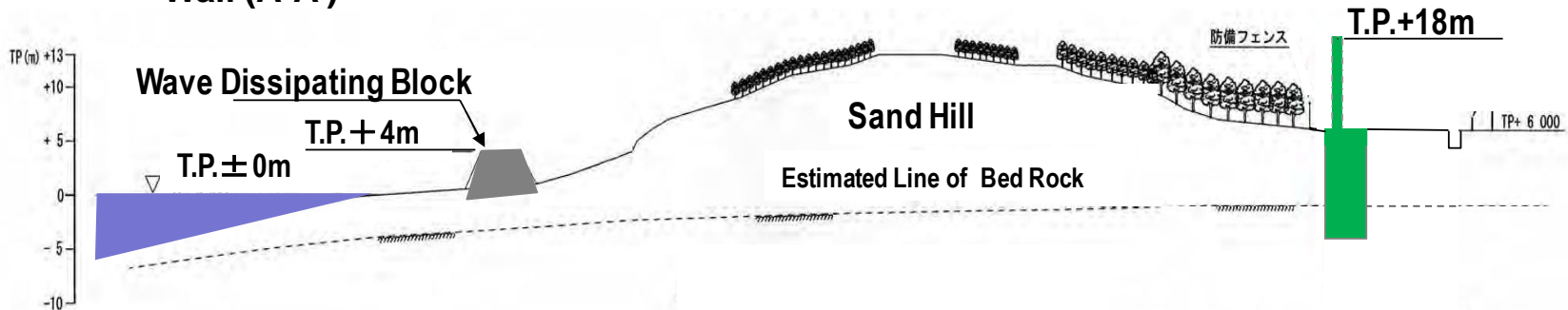


Image of The Sea Wall

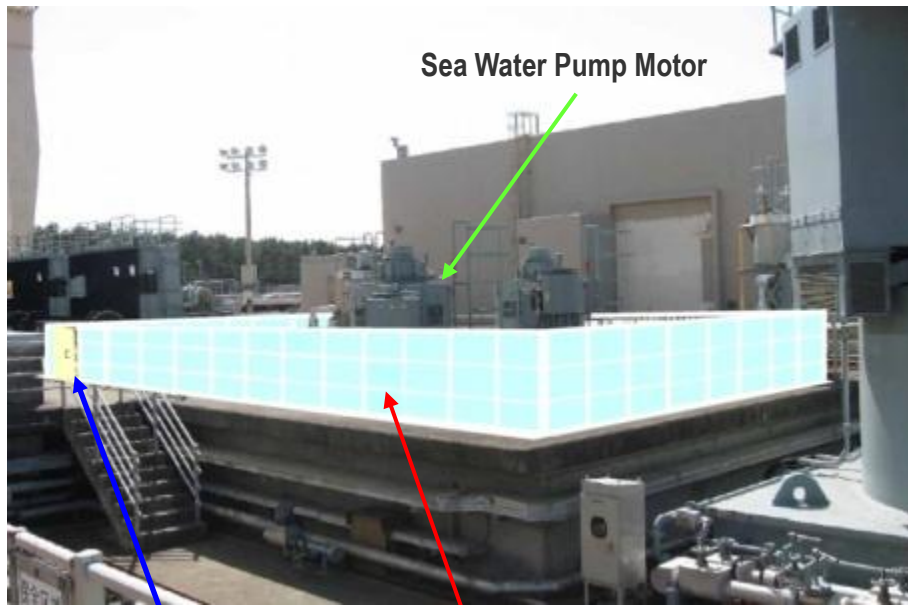
To prevent tsunami from intrusion into the site, we will install the sea wall, **T.P. +18 m** height and 1.6 km length) between the PS and the sand hill as well as side area of the PS. The edge of the west and east area of the wall will be connected to the place which has ascended to **maximum 20 m** height from the sea level.



Sand Hill and Cross Section of Sea Wall (A-A')

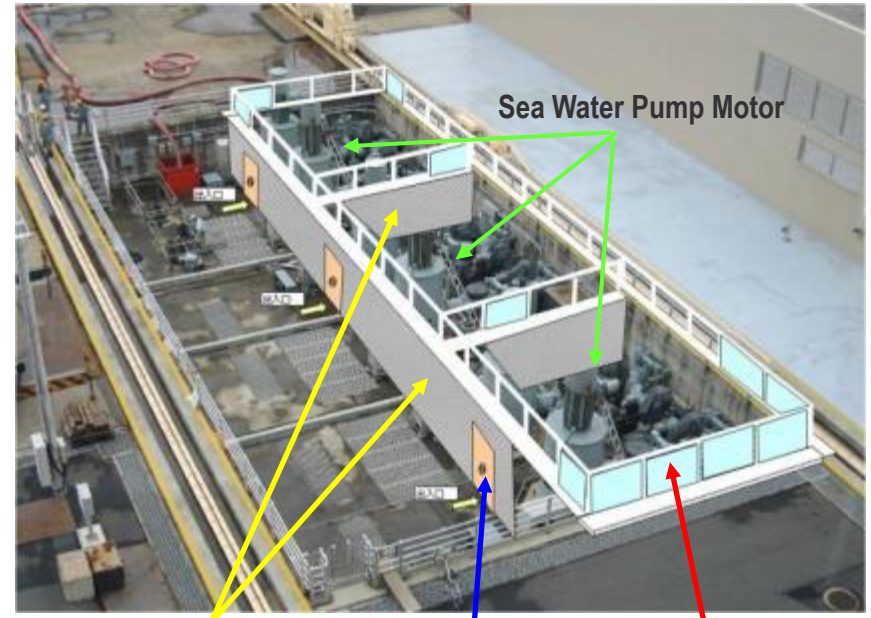


- Because sea water may overflow in a site from a part connected to the seas, such as an intake water pond, at the time of tsunami generating and the sea water pumps located outside of the plant may be flooded, a 1.5-m-high protection wall is installed surrounding the area of sea water pump.



Door to Access to the Area

Protection Wall Made by Aluminum



Partition Wall Made by Concrete

Door to Access to the Area

Protection Wall Made by Aluminum

Images for Protection Wall

Prevention of Flooding Inside the Building

Assuming the case of tsunami exceeds the seawall and flooding inside the power station site. In this case,

- The sea pumps located outside of the building would shutdown because of flooding. As a result, the plant loses the sea water cooling system
- The case may also lead to flooding inside the building.

Considering the situation, we will implement 3 types of countermeasures:

- (1) Maintaining sea water cooling function; (2) Prevention of Flooding Inside the Building; (3) Prevention of Flooding Inside the Equipment Containment Room

(1) Maintain Sea Water Pump Function

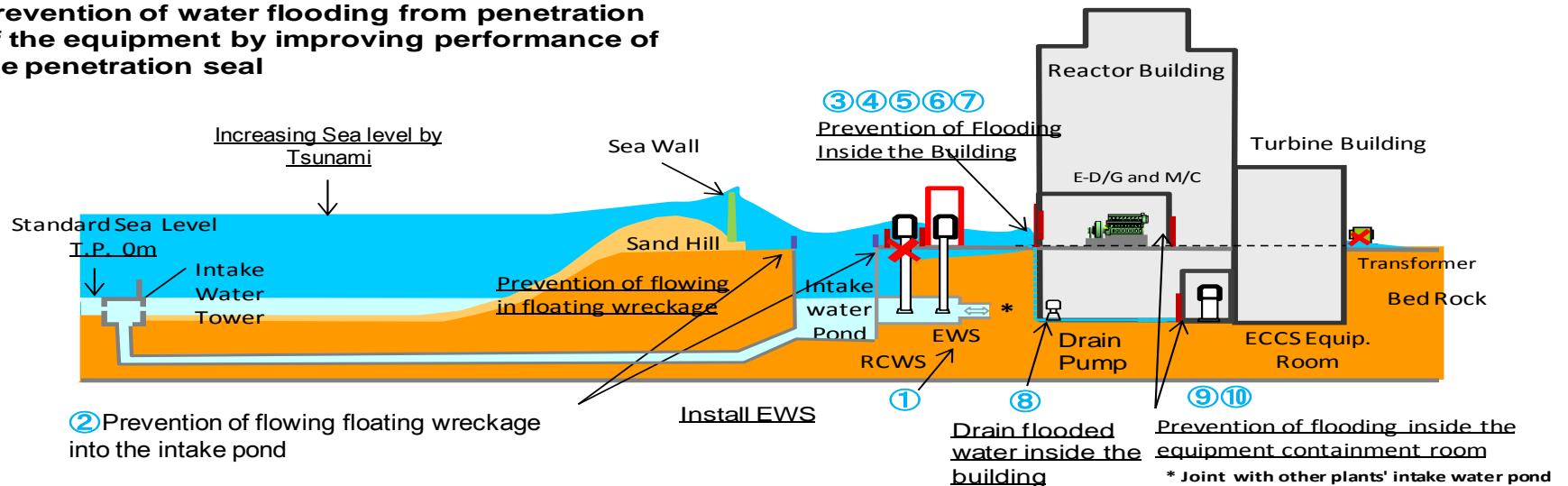
- ① Install Emergency Sea Water System (EWS) as an alternative of RCWS
- ② Prevention of entering debris into the intake water pond

(3) Prevention of Flooding Inside the Equipment Containment Room

- ⑧ Set drain pump to strength draining from the building
- ⑨ Adding watertight doors and reinforcement of the doors
- ⑩ Prevention of water flooding from penetration of the equipment by improving performance of the penetration seal

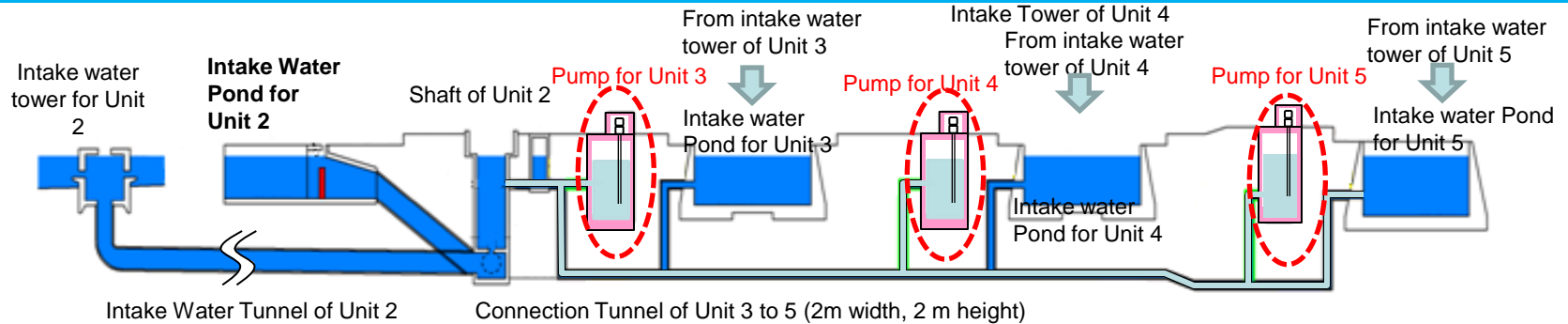
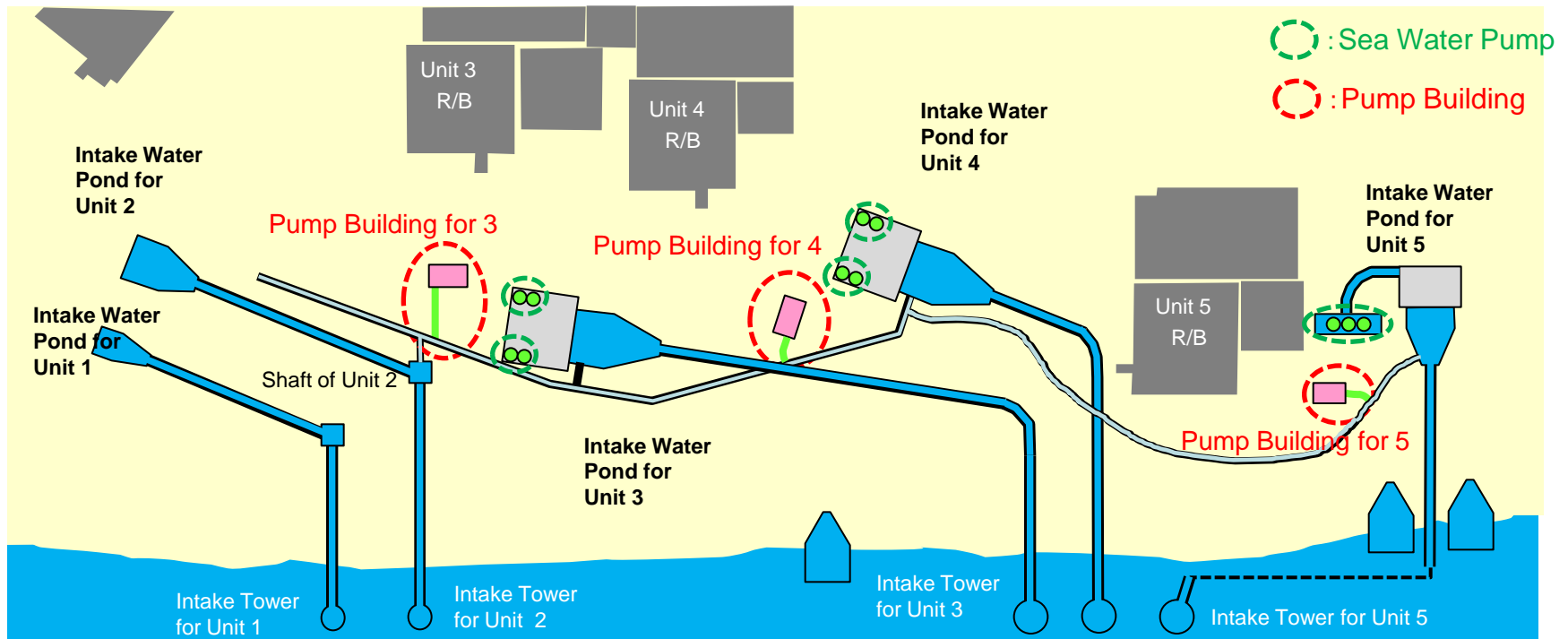
(2) Prevention of Flooding Inside the Building

- ③ Reinforcement and improvement of reliability of the protection doors
- ④ Prevention of water intrusion from exhaust line that open to the outside
- ⑤ Prevention of water flooding from the penetration by improving performance of the penetration seal
- ⑥ Closed several entrance doors and inspection windows for underground pipe duct
- ⑦ Reinforcement of the building against water pressure during flooding



Ensure Sea Water Cooling System

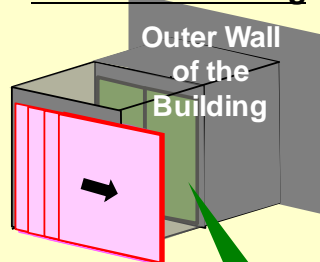
As an alternative for RCWS, we will install Emergency Sea Water System "EWS" to Unit 3 to 5. Specifically, the pumps are contained inside the newly installed building with water protection structure. As a result, the sea water cooling function can be maintained without affect from flooding. Furthermore, EWS enables multiple water source of seawater by connecting seawater tunnel from Unit 2 to Unit 5.



Regarding the prevention of flooding inside the building

- ◆ To install duplication of protection doors to improve reliability of the water protection doors of outside of the building.
- ◆ To install sliding flood barrier for loading door, and duplication of reinforcing the doors and watertight door.
- ◆ To change the shape into snorkel type of exhaust line that open to the outside

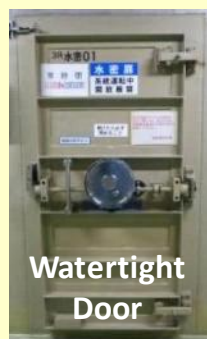
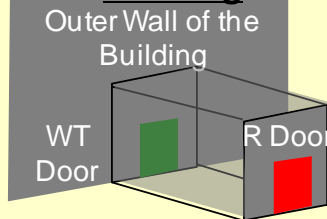
Prevention of Flooding Inside the Building



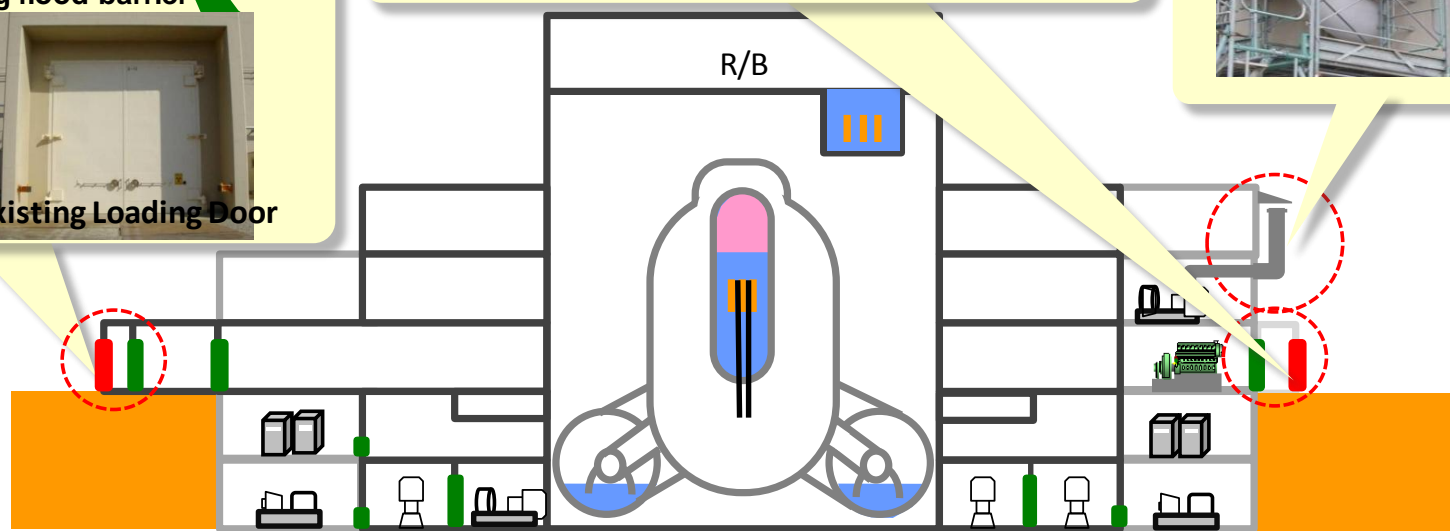
sliding flood barrier



Prevention of Flooding Inside the Building



Prevent water intrusion from Feeding and Exhausting Line

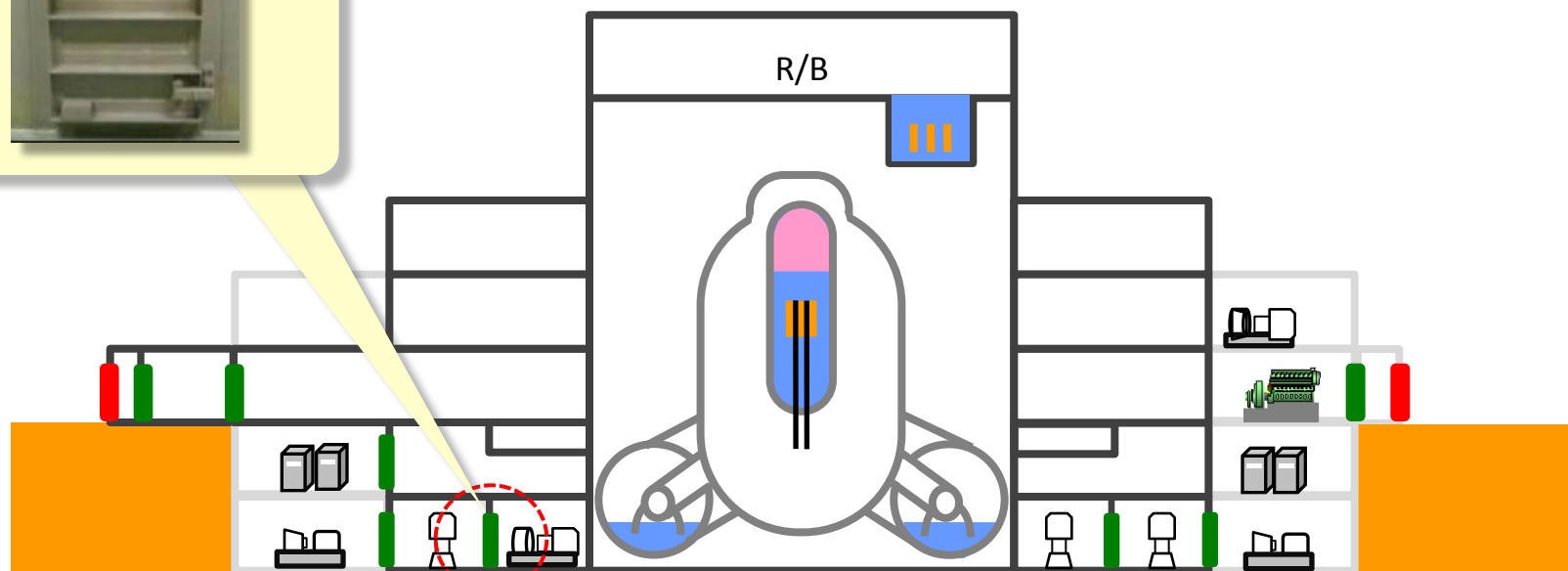



 : Inside the Radiation Control Area
 : Outside the Radiation Control Area

Prevent Flooding Inside the Equipment Room



- ◆ In addition, important equipment and power supply relating with cooling function locate inside individual room inside the building; therefore, addition to prevent flooding inside the building, we will carry out the measures to prevent flooding inside the equipment room.
- ◆ Specifically, strengthen draining measurement, adding watertight door or reinforcement, and prevention of water flooding from the penetration area for the equipment room.



 : Inside the Radiation Control Area
 : Outside the Radiation Control Area

◆As a further measure, even assuming both Station Black Out (SBO) and Loss of Sea Water Cooling Function that occurred at the Fukushima-Dai-ichi NPS, we will take measures for alternative method viewing from multiplicity and diversity against injection/heat removal/power supply functions. To do so, we will maintain the reactor with hot shutdown in stably, and finally lead to cold shutdown with safety and reliable manner

Assumption

- ◆SBO: Loss of all AC power including emergency DG and switchgear function
- ◆Loss of Sea Water Cooling Function: Both existing Sea Water Cooling Pump (RCWS) and install Emergency Sea Water Cooling System (EWS) are not available.

Alternative method to ensure cooling reactor and fuel pool

By Securing Alternative Measurement

Water Injection

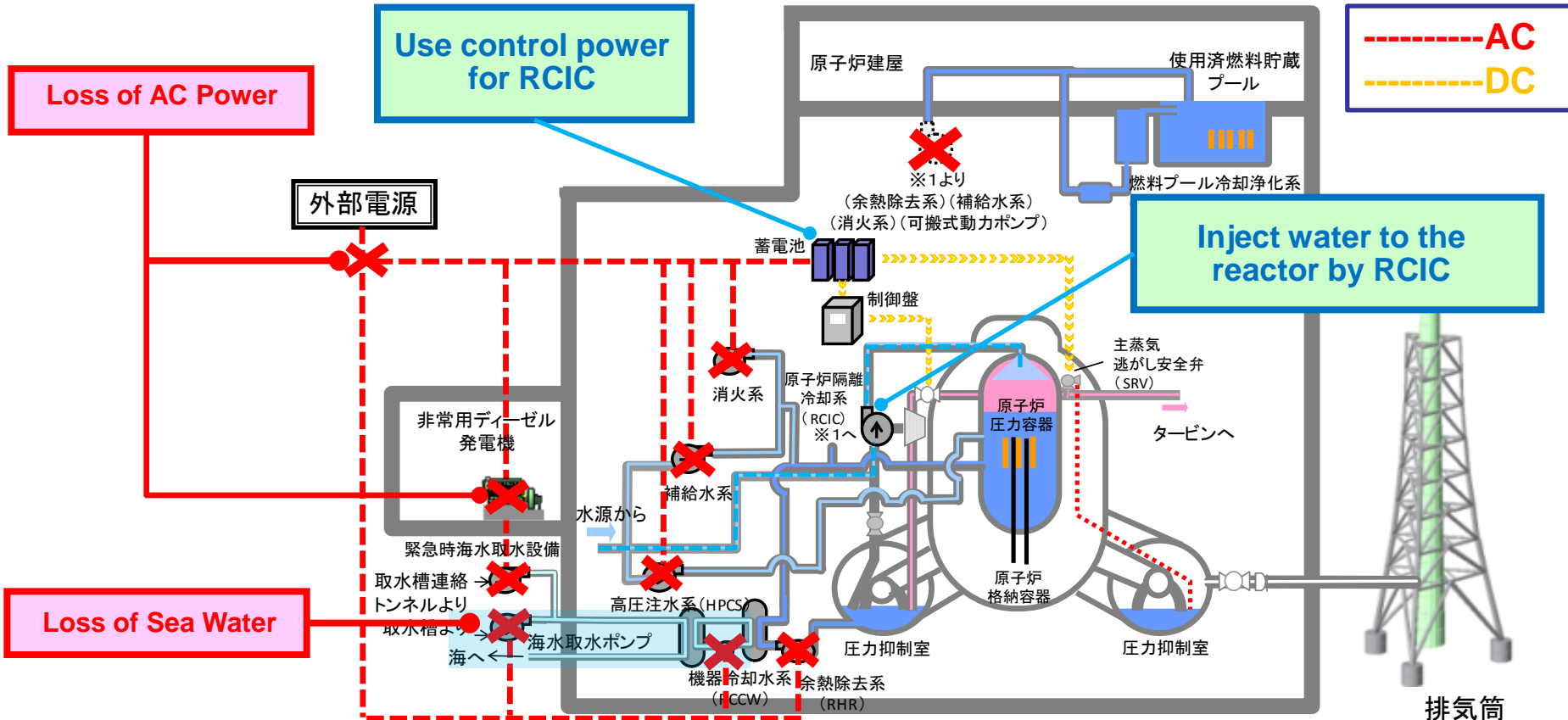
Heat Remover

Power Supply

Lead to Cold Shutdown

Outline of SBO and Loss of Sea Water Cooling Function

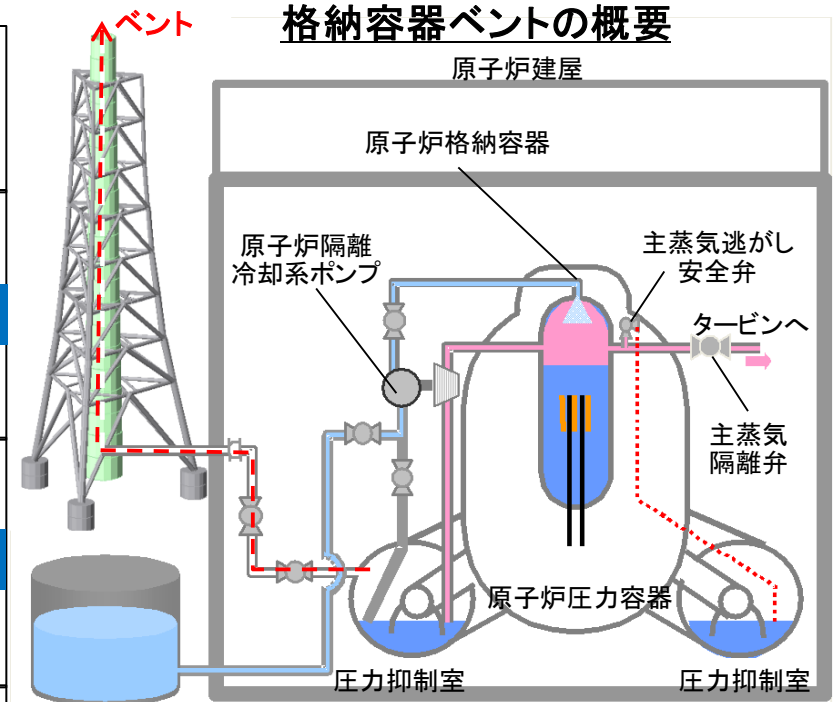
- ◆ Losing all AC power caused to shutdown pumps for cooling or injecting water to the reactor, and system for releasing heat from the reactor.
- ◆ By losing sea water cooling system, it could not exchange heat with sea water, then it could remove heat from reactor and equipment
- In the case, RCIC "Reactor Core Isolation Cooling" works to inject water to the reactor. The RCIC uses steam from the reactor by applying turbine pump and it has a function of injection water to the high pressure of the reactor even in the case of SBO, by using the battery, which can work 8 hours on the design basis.



Flow to Achieve Cold Shutdown

- To lead to the reactor cold shutdown, securing injection water system for cooling the reactor is important. Simultaneously, ensuring power supply and water source is also important.
- Cooling through injecting water together with decreasing pressure through PCV vent can lead to hot shutdown and maintain stably.
- Restoring Sea Water Cooling Function in early stage is critical to lead to cold shutdown.

Time Line	<div style="background-color: yellow; border: 1px solid black; padding: 5px; text-align: center;">SBO, Loss of Sea Water Cooling System</div> <div style="text-align: right; color: blue;">▼ Cold SD</div>
Injection	<div style="background-color: blue; border: 1px solid black; padding: 5px; text-align: center;">Continuous water injection to the reactor is important</div>
Heat Removing	<div style="background-color: pink; border: 1px solid black; padding: 5px; text-align: center; margin-bottom: 5px;">PCV vent</div> <div style="background-color: blue; border: 1px solid black; padding: 5px; text-align: center; margin-bottom: 5px;">Return SW Pump</div> <div style="background-color: green; border: 1px solid black; padding: 5px; text-align: center;">Restoring Sea Water Cooling Function</div>
Power Supply	<div style="background-color: green; border: 1px solid black; padding: 5px; text-align: center;">Ensure power supply of injection and heat removing is important</div>



◆ As the steam generated from the reactor, the pressure inside the Primary Containment Vessel increase as well. As a result, implementation of releasing the pressure by venting is necessary to maintain PCV soundness.

Reinforcement of Emergency Measures are roughly divided into 4 category.

(1) Measures for Injection water

Equipment

(2) Measures for Residual Heat Removing

Equipment

(3) Measures for Power Supply System

(4) Others

Reinforcement of Emergency Measures

Ensuring Cooling System

(3) Power Supply

- ⑩ Install Emergency AC power generator (gas turbine generator) on the backyard hill
- ⑪ Install standby generator for disaster management
- ⑫ Prepare for spare battery
- ⑬ Install backup switchgear or power cubicle to the higher place

(4) Others

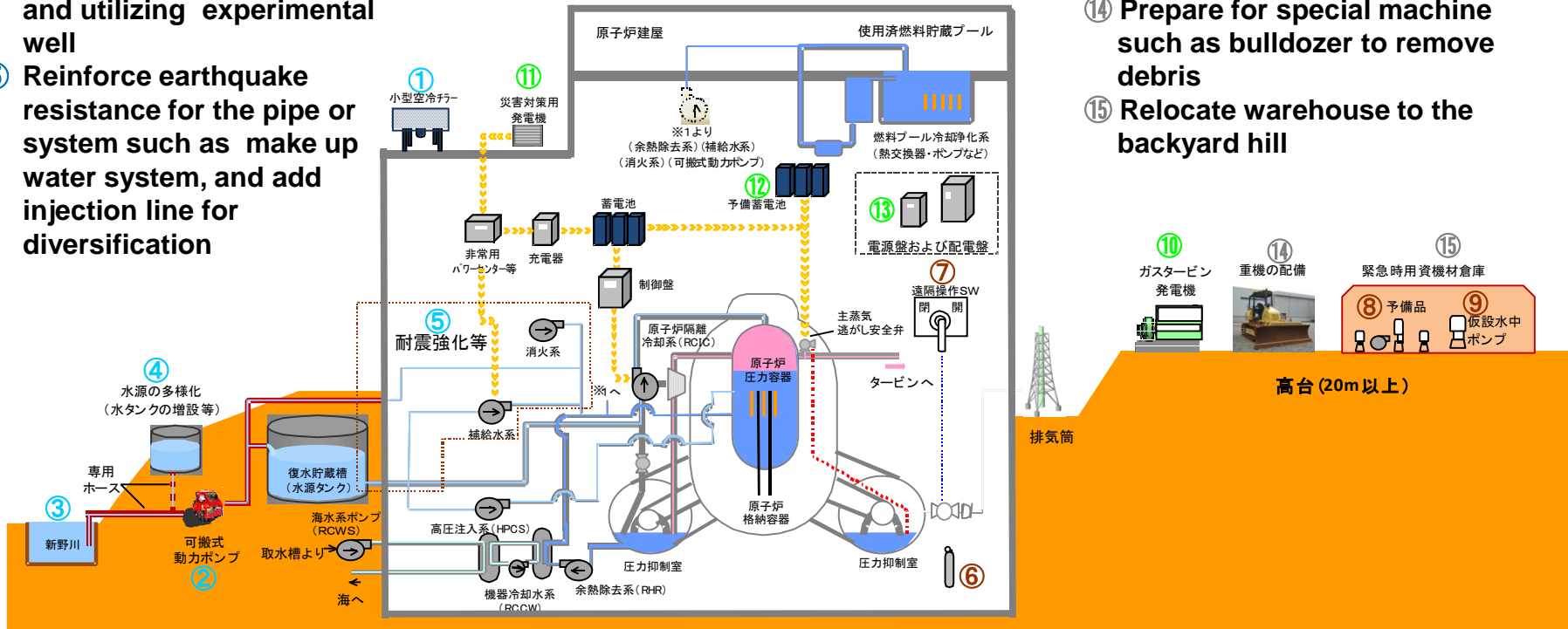
- ⑭ Prepare for special machine such as bulldozer to remove debris
- ⑮ Relocate warehouse to the backyard hill

(1) Injection

- ① Secure alternative cooling equipment to be available for HPCS system (Air Cooling Chiller)
- ② Secure mobile pump
- ③ Establish intake water method from the Niino River
- ④ Diversify water source through adding water tank and utilizing experimental well
- ⑤ Reinforce earthquake resistance for the pipe or system such as make up water system, and add injection line for diversification

(2) Heat Removal

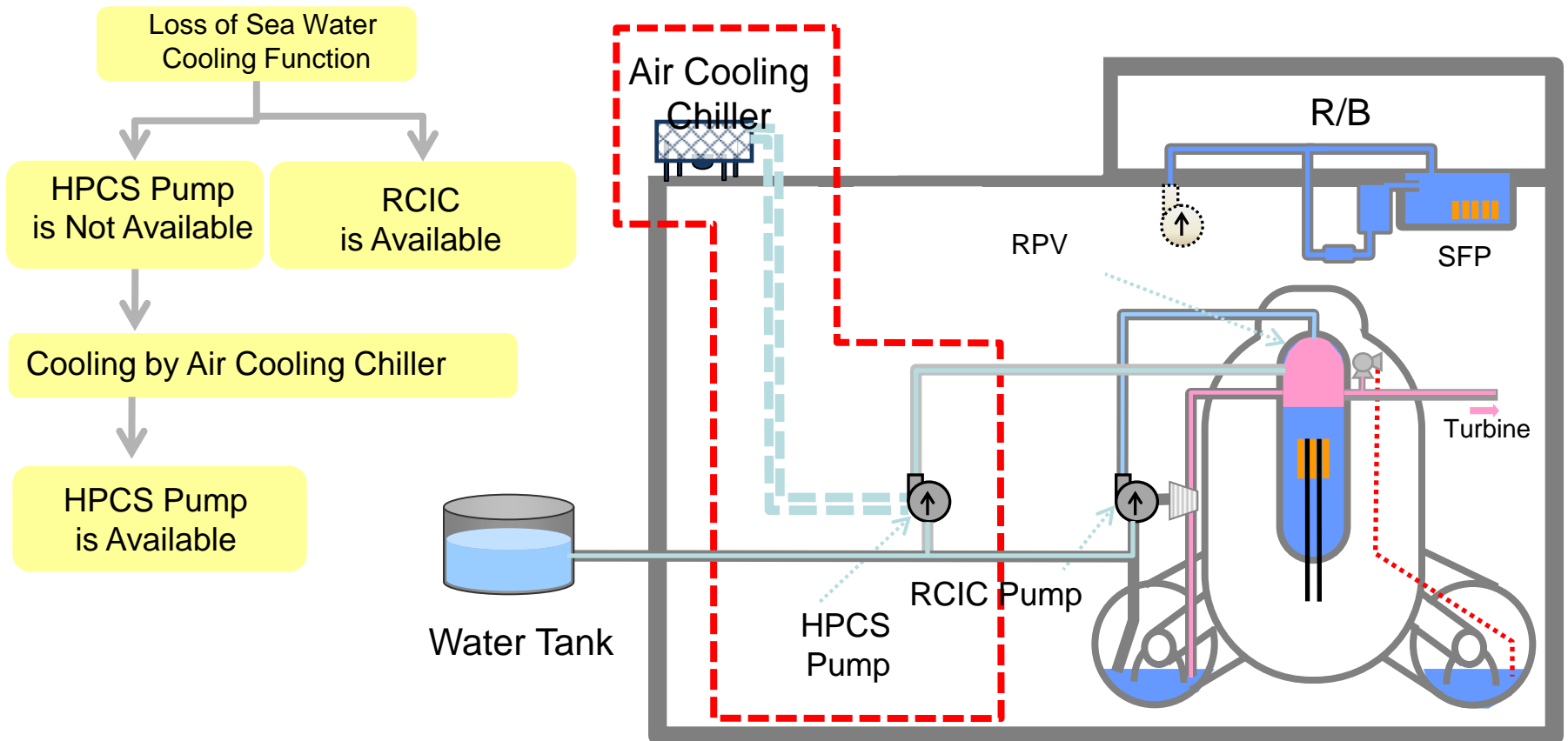
- ⑥ Set nitrogen cylinder to operate PCV vent
- ⑦ Remote control of the valve operation for PCV vent
- ⑧ Prepare for spare motor and pump of RCWS, RCCW, and RHR
- ⑨ Prepare for underwater-pump for the alternative of RCWS pump



Water Injection System^①

Diversify High Pressure Injection Function

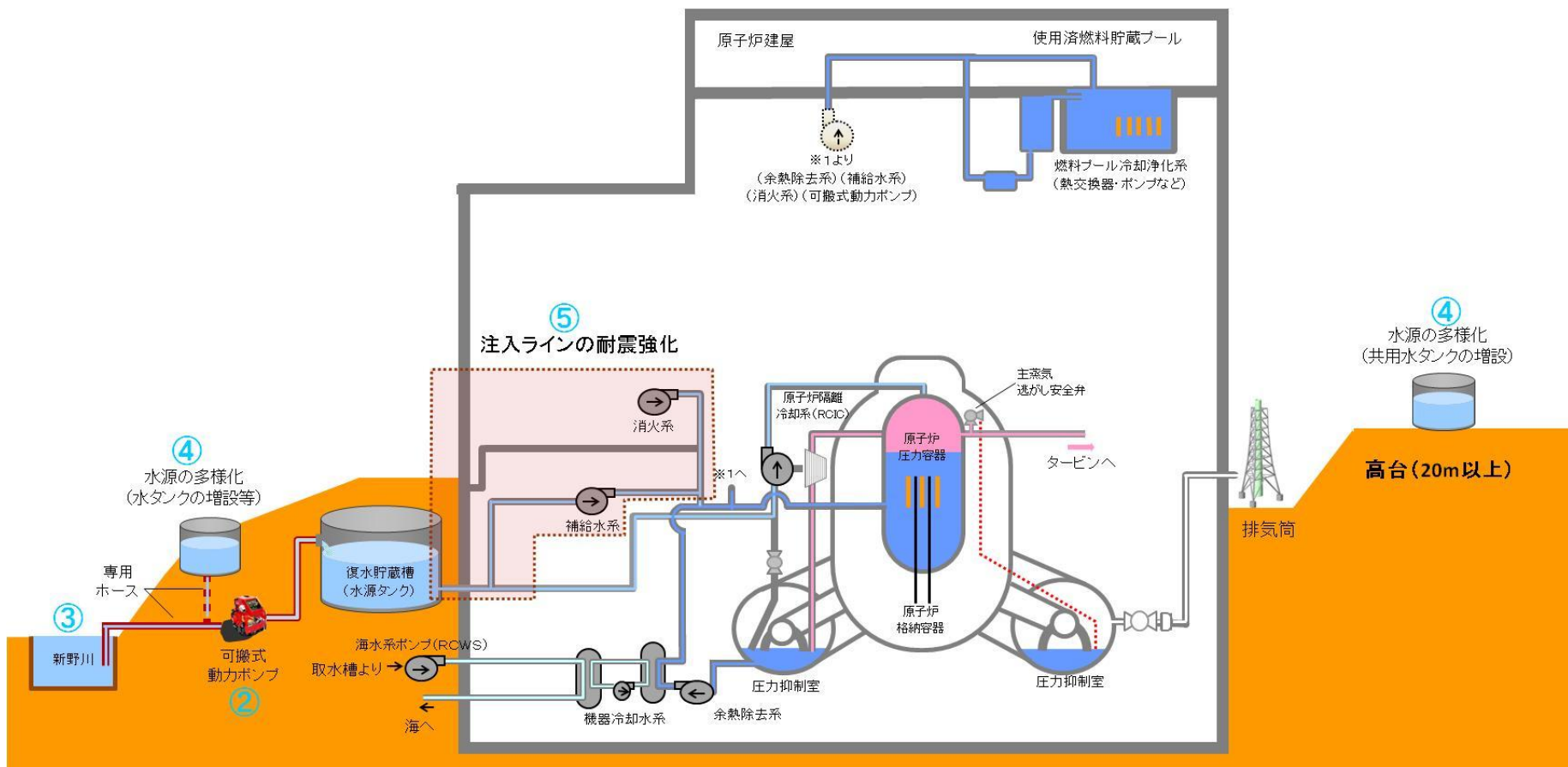
As for back up of High Pressure Core Injection function during the loss of sea water cooling system, we will install air cooling chiller to be available for HPCS in the case of losing function of sea water cooling function.



Improve Reliability By Diversifying Water Source and Reinforcing Resistance Against the Earthquake for Feeding line

- Increase Water Source Tank and improve reliability against the earthquake of the feeding line

We will install new water source tank to inject water to the reactor and spent fuel pool, and reinforce resistance against the earthquake for the water feeding line or install seismic S class of feeding line.



Heat Removal ⑥⑦

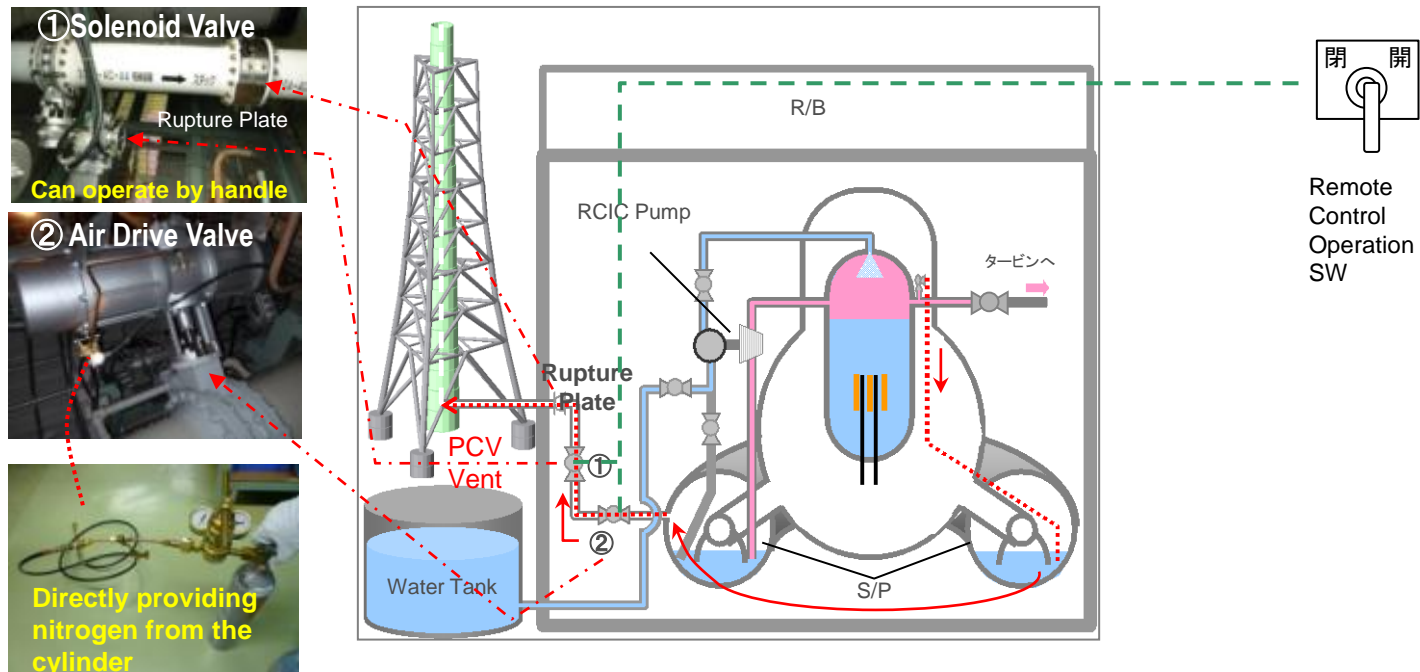
Reinforcement of PCV Vent System

● Set nitrogen cylinder to operate PCV vent

In the case of losing AC power, we set nitrogen cylinder at the site on April 11, 2011, to be available for quick operation.

● Remote control of the valve operation for PCV vent

It enables operators to operate the valve in the MCR and response quickly without going to the site. Also the power is supplied from the Emergency AC Power Generator supposed to be installed at the backyard hill.

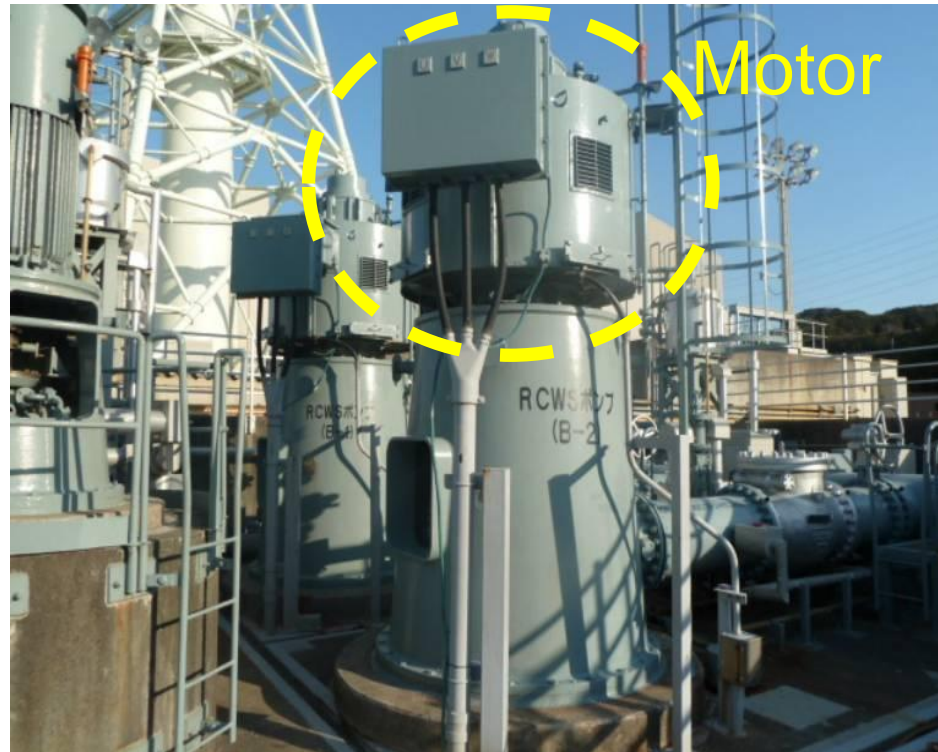


Steam generating from the reactor core, the pressure of PCV rise up. Therefore, to maintain soundness of the PCV, vent is necessary to release PCV pressure.

Prepare for Spares for Ultimate Heat Sink

● Prepare for Spares for Sea Water Pump

Prepare for spares of equipment of reactor cooling in the case of malfunction of the equipment



Sea Water Pump "RCWS pump"

While continuing water injection to the reactor and spent fuel pump, we restore the sea water cooling system. To do so, it is available to lead cold shutdown about a week.

Diversify the power source and increase reliability

⑩ Install Emergency AC Generator

We will install emergency AC Generator at the backyard hill where does not be affected by tsunami.

The purpose is to provide the power to the ECCS in the case of outside power and emergency D/G are not available while the newly install power generator set them at hill without fear from tsunami.

⑬ Install backup switchgear or power cubicle to the higher place

To install switchgear or power cubicle for providing power to each equipment at higher place.

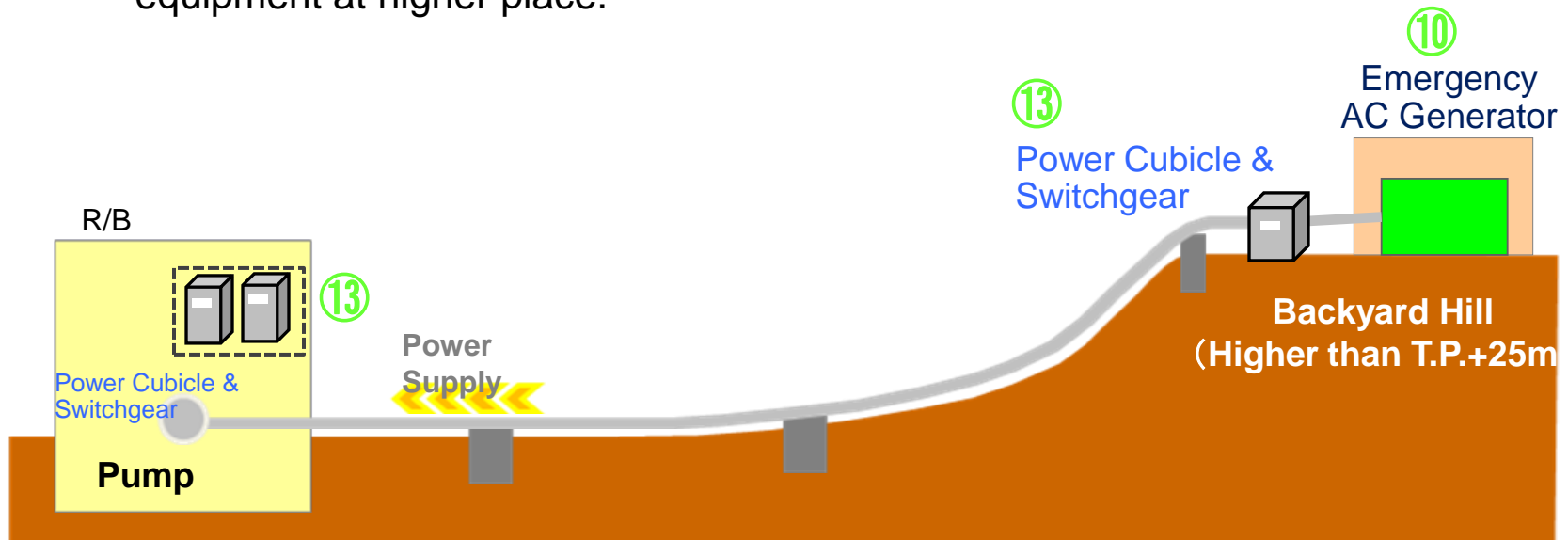
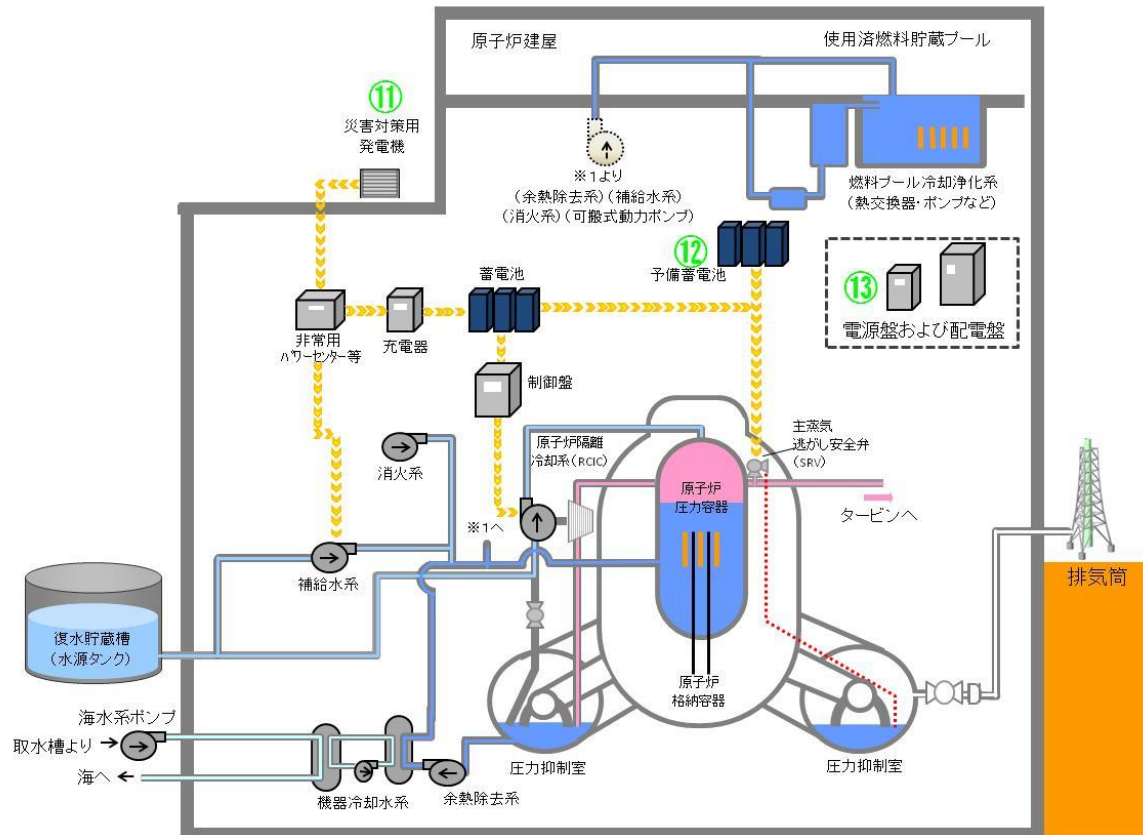


Image of providing AC power form the emergency power generator

Diversify the power source and increase reliability

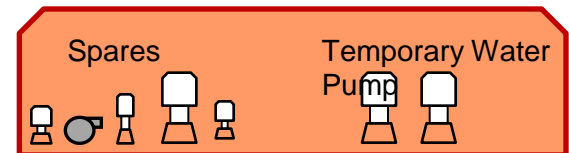
- ⑪ Install standby generator for disaster management on the roof of the building
- ⑫ Prepare for spare battery



⑭ Relocate warehouse to the backyard hill

Spares parts or equipment for using during emergency are kept inside the exclusive warehouse that newly installed.

Exclusive Ware House keeping for Emergency Equipment



Backyard Hill
(More than T.P.+25m)

⑮ Prepare for special machine such as bulldozer to remove debris



Wheel Loader



Bulldozer



Crawler Carrier



Hydraulic shovel
(Tip of the arm is replaceable)

As it shows, by implementing multiplicity and diversify the measures, even if we faced with severe situation such as both of **SBO** and **Loss of Sea Water Cooling System**,

① We can **stably maintain hot shutdown** by strengthen of injection/heat removal/power supply system.

② Also, with restoring sea water system in early stage, we could **lead to cold shutdown**.

Improve reliability of External Power Supply

- Regarding our protection measure, we estimate loss of external power supply
- Not expected on external power but measure by emergency generator
- However, quick restoration of power supply is necessary

< Improve Reliability of External Power Supply >

① Increase receiving line for Unit 5 (2 roots → 3 roots)

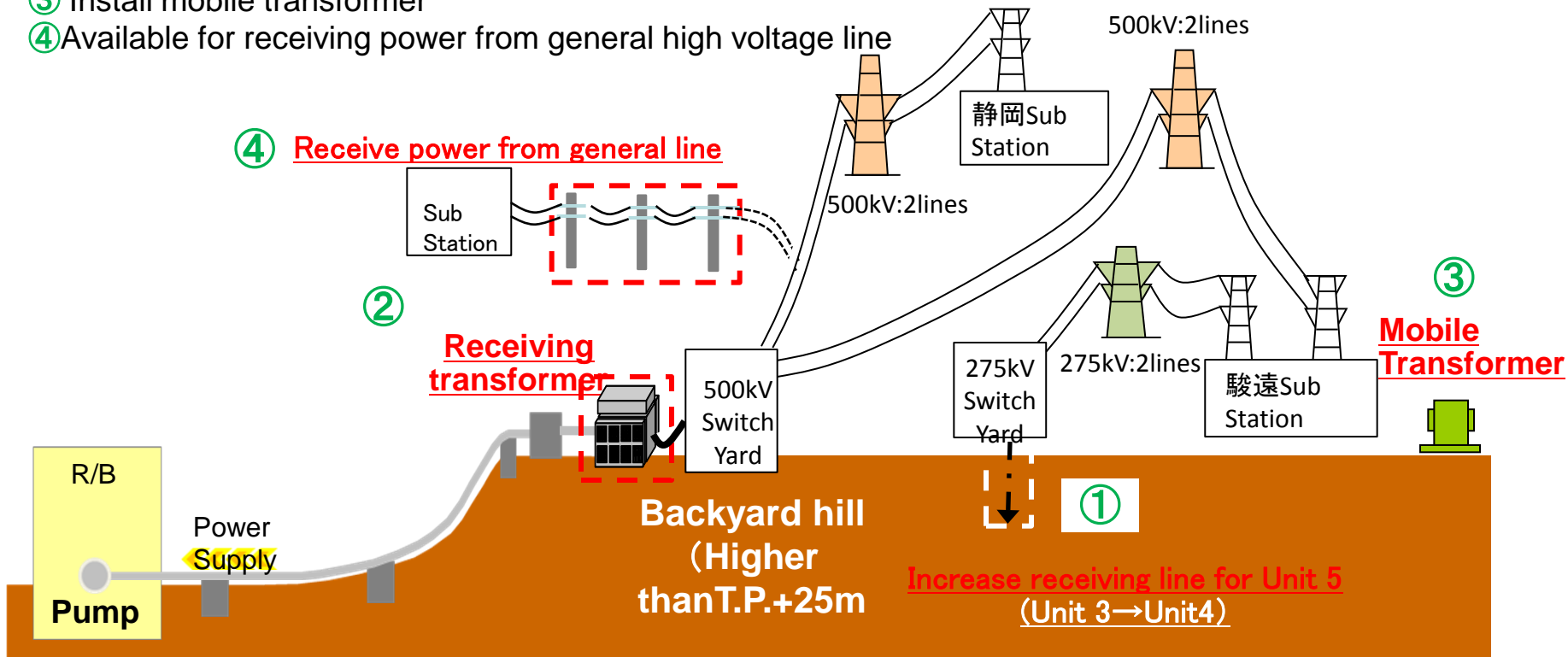
※Unit 3 & 4 have 3 roots already

< Measures for Flooding (After restoring External Power >

② Install receiving transformer on the backyard hill

③ Install mobile transformer

④ Available for receiving power from general high voltage line



Based on the accident at Fukushima, we drastically will review our disaster protection management .

- Previously, we did not estimate nuclear disaster associated with earthquake and tsunami; however, we will estimate compound type of disaster and prepare for appropriate system.
- Not only to prevent from the accident at Fukushima, but we also take into account disaster control and management under the severe accident with group companies of Chubu EPC.
 - ✓ To manage compound type of disaster, arrange the organization & system and prepare for materials
 - ✓ Implement the training
 - ✓ Prepare enough number and quality of radiation control staffs and materials
- Regarding communication to the local residents and management of evacuation residents that would be conducted by the government or local residents, it is necessary to cope with local government to work together by reflecting Fukushima Dai-ichi accident. Also we will actively join the revise of Plan of disaster prevention plan for the local government through providing our knowledge

We set the target of completing construction work of tsunami countermeasures that we announced today by December 2012.

Also, to lead to the public confidence, we will continue our best for both of our activities such as pursuing further safety and explaining to the public with respectfully.