Evaluation of the Total Exposure Reduction Measures during Construction of the Land-side Impermeable Walls Using the Frozen Soil Method

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1F Frozen Soil Impermeable Walls Construction Office

Kajima Cooperation

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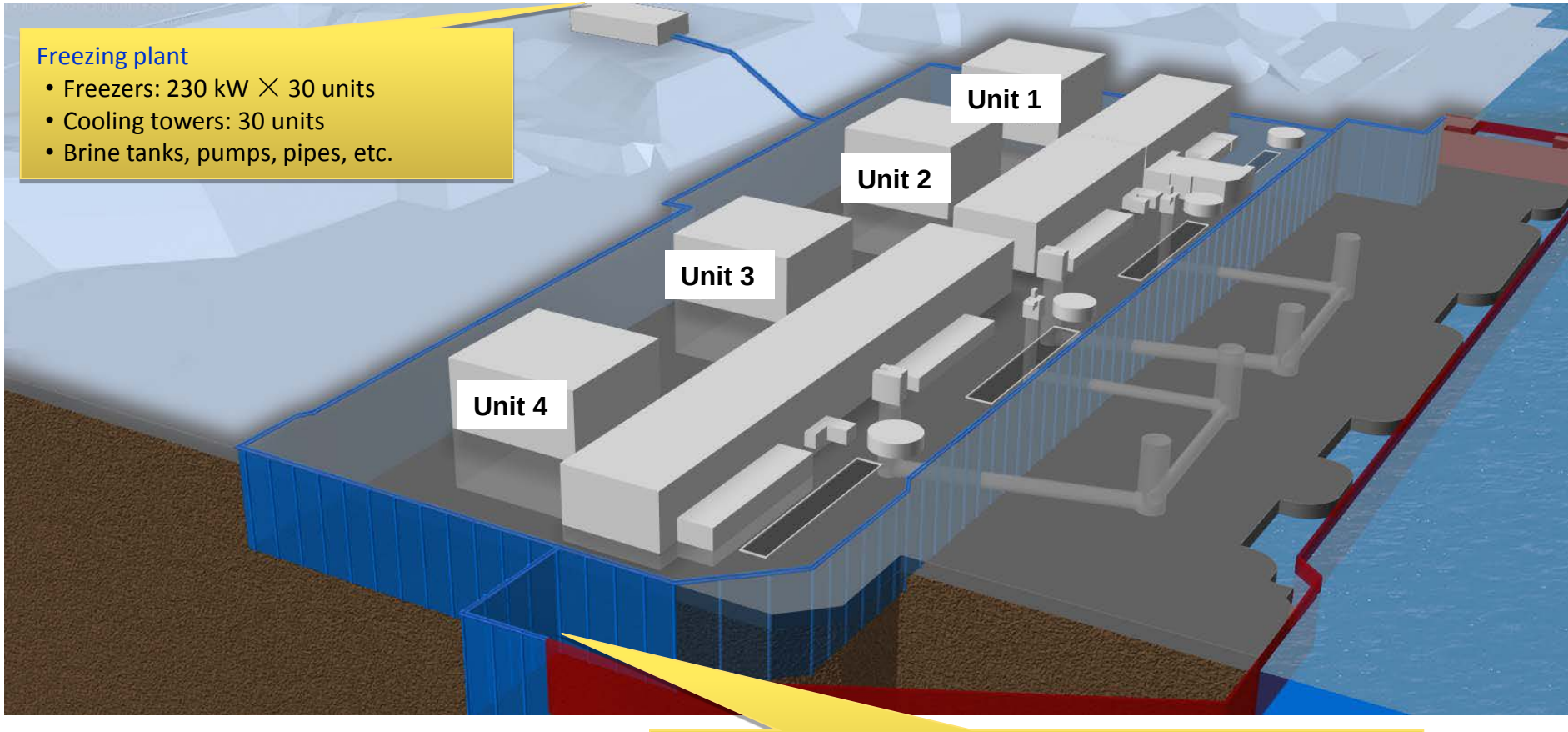
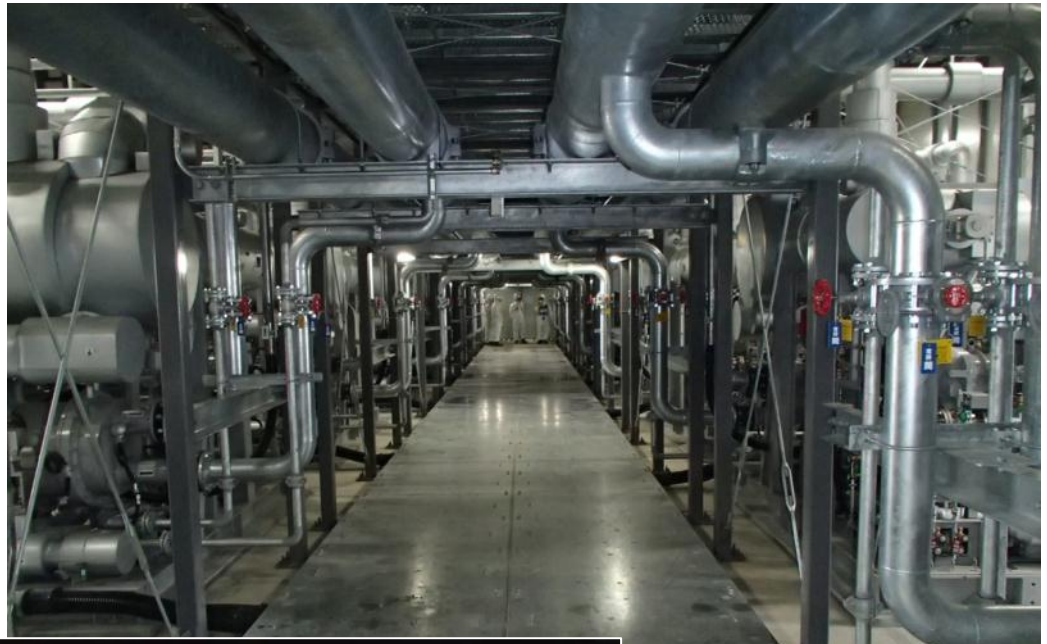
1. Overview of the work

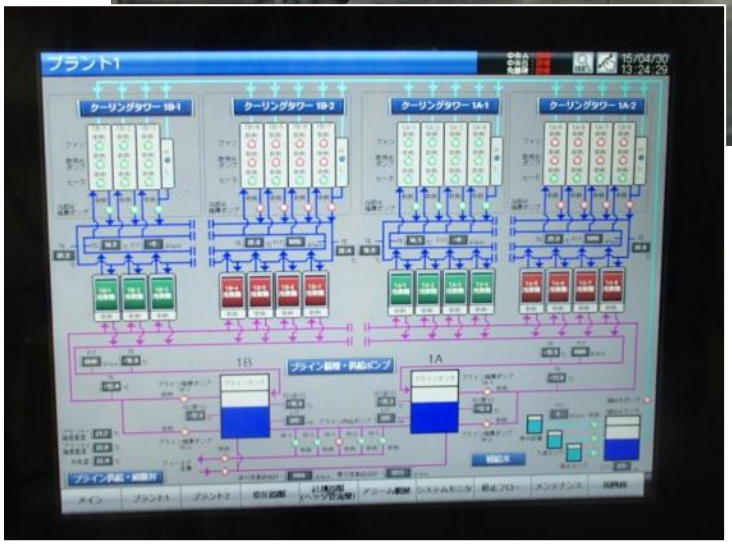
Overview of the whole works

Image of the Construction of the Impermeable Walls Using the Frozen Soil Method



Construction site: freezing plant (Central Monitoring Room, 30 refrigeration machine)



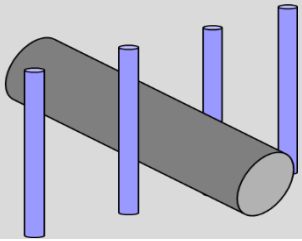


Construction site: brine piping

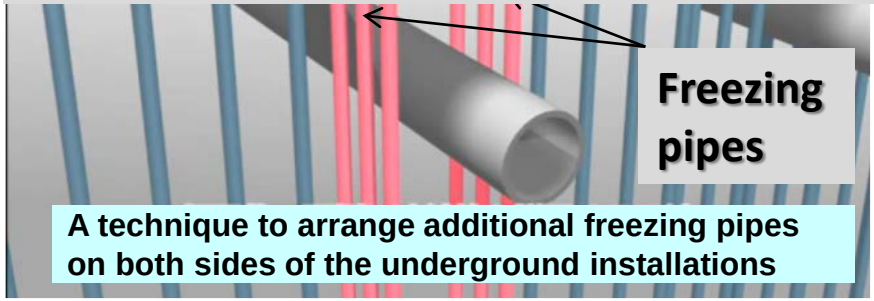
Overview of construction: concept to handle underground installations

Three options for arrangement of freezing pipes to the underground installations

①Single-line arrangement:
Arrange freezing pipes in a single line
- **Without underground installation**
- **With small underground installations (mountain side @1.0 m, sea side @1.2 m)**



②Multiple-line arrangement:
Arrange multiple freezing pipes on both sides of the underground installations
- **For underground installations with width < 3 m**
- **4-line arrangement (< 1.5 m), 6-line arrangement (< 2.5 m)**

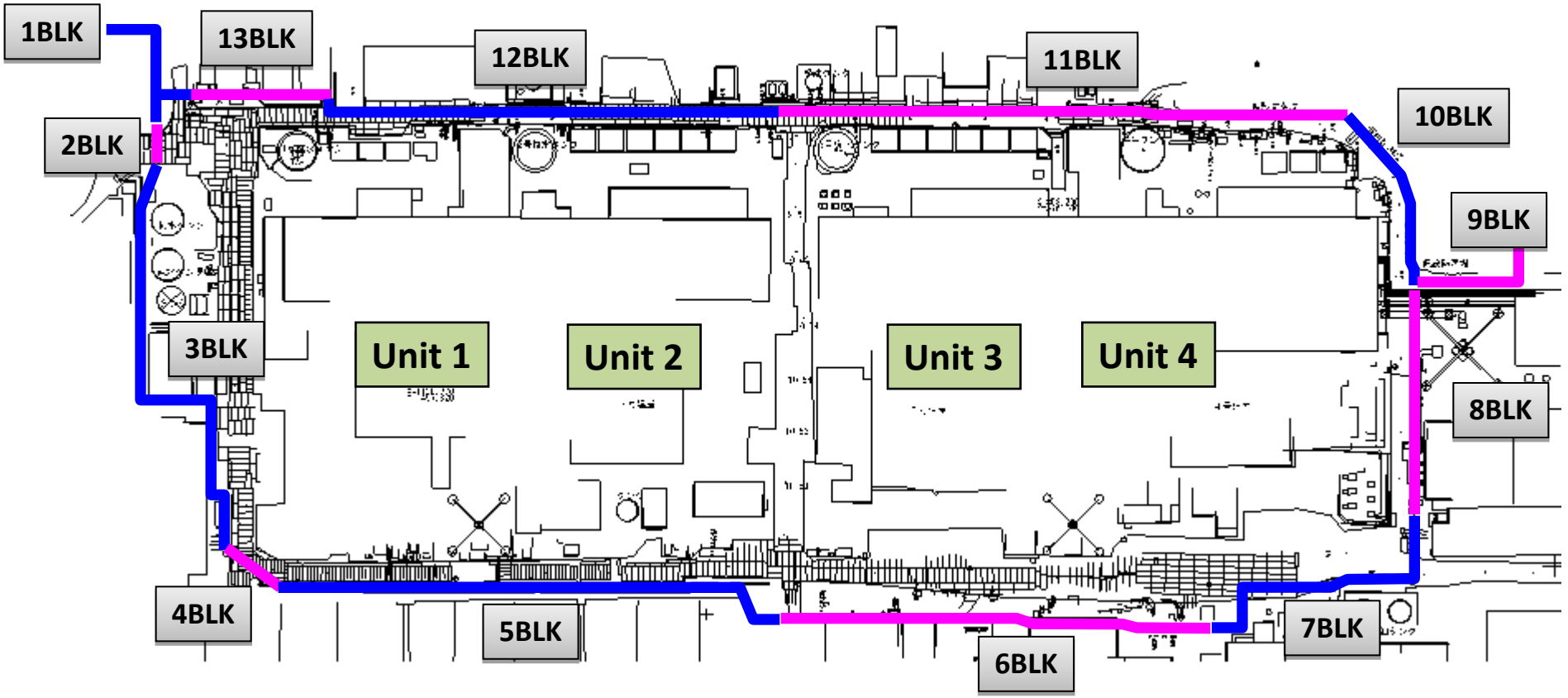


③Penetrating arrangement:
Pipes penetrating the underground installations.
- **For underground installations with width > 3 m**

Construction progress: drilling

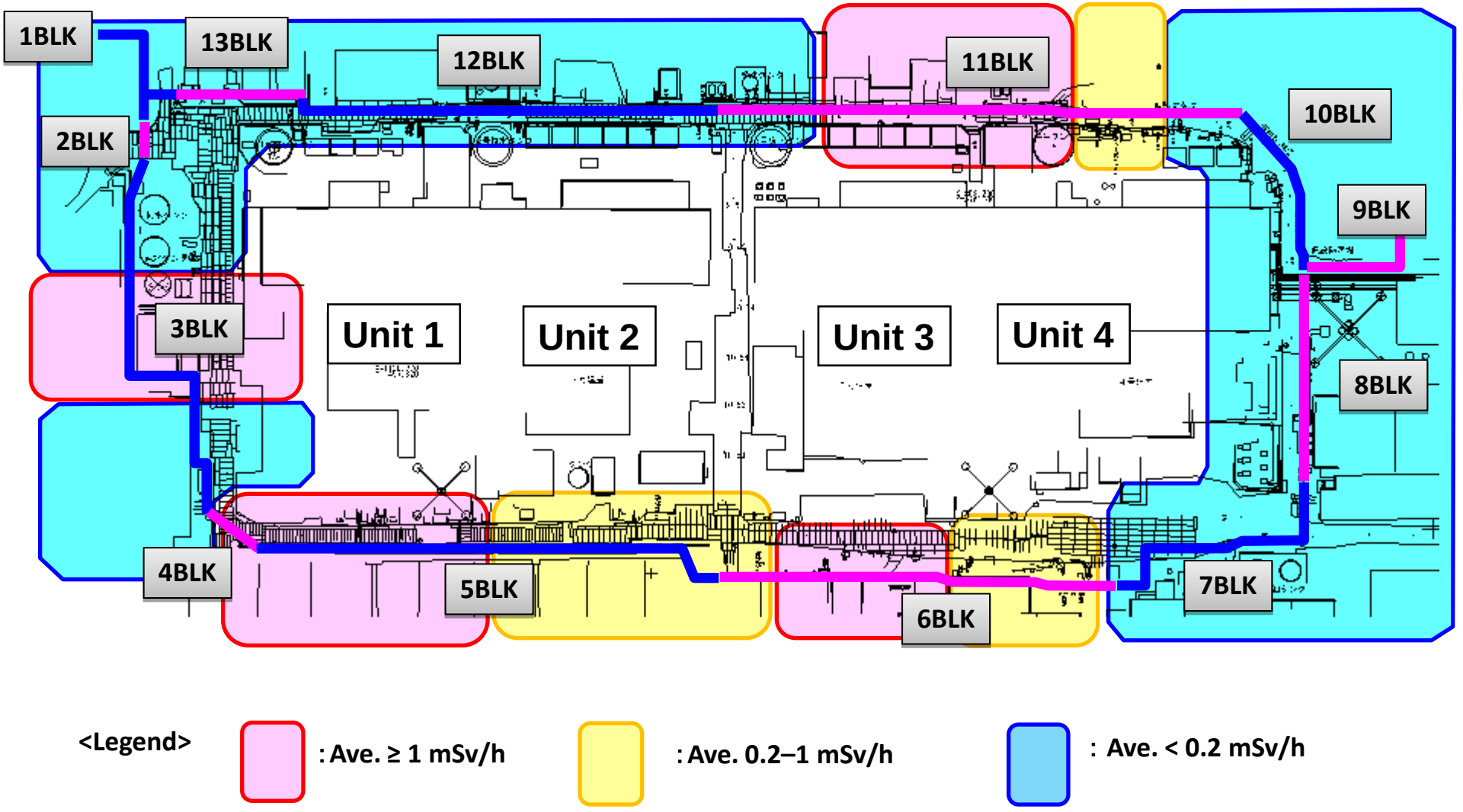
2. Measures for reduction of air dose rate

Radiation dose rate map (ave. dose rate before construction)

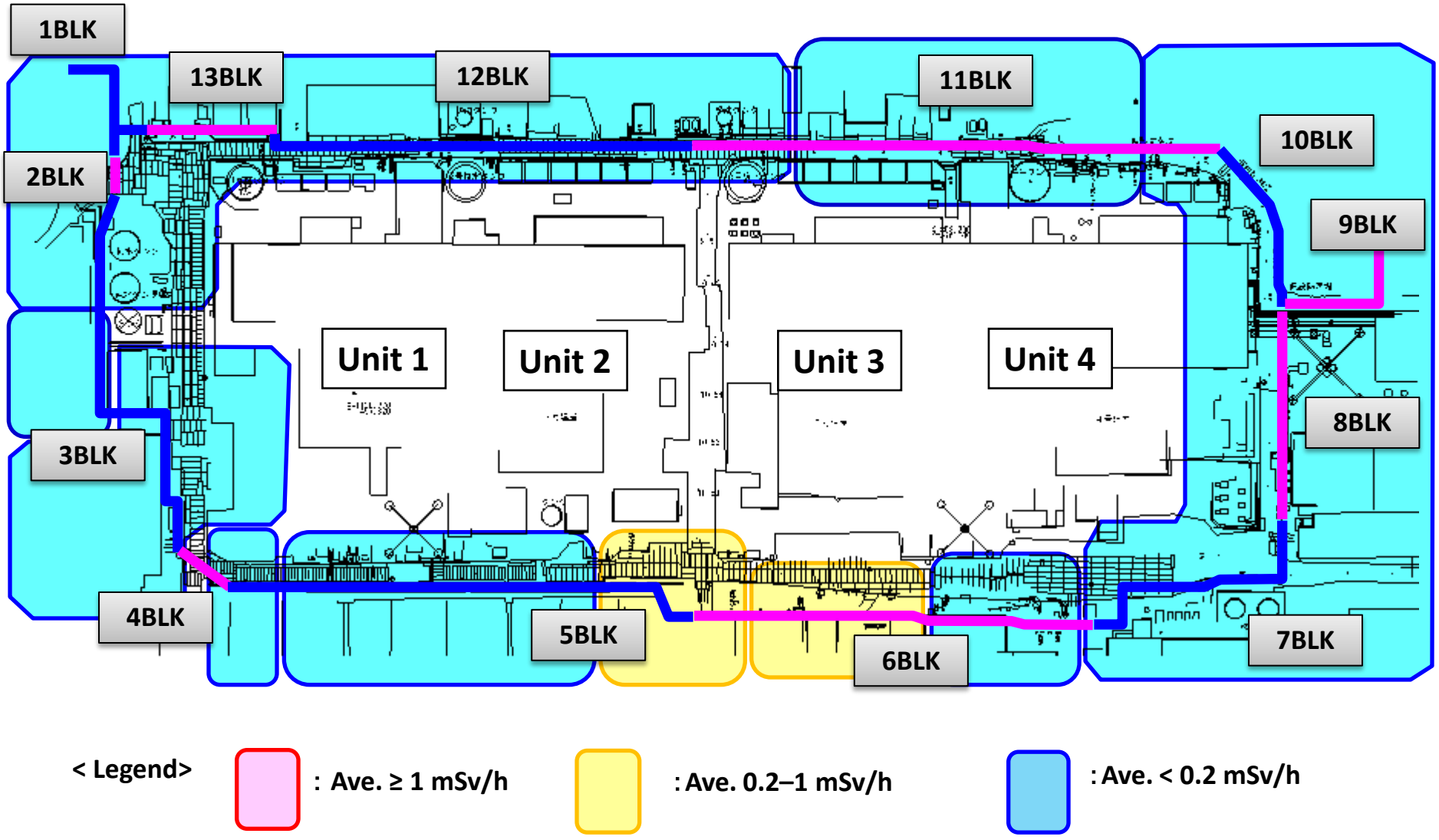


Block	1	2	3	4	5	6	7
Ave. dose rate (mSv/h)	0.03	0.21	0.56	0.26	1.2	0.85	0.1
Direction of sources			Building	Building	Building, Slope	Building, Slope	
Block	8	9	10	11	12	13	Total average
Ave. dose rate (mSv/h)	0.13	0.19	0.1	0.59	0.14	0.24	0.35
Direction of sources				Building	Building		

Radiation dose rate map (March 2014: at the start of construction)



Radiation dose rate map (September 2015: 18 months after construction)



Implementation of the measure for radiation exposure reduction (1): 3-Block Areas

Reduction measure: crushed stone pavement and installation of L-shaped protective walls

Before the measure
(radiation sources: ground surface/ left side building)

Air dose rate:
1.0–2.0 mSv/h

After the measure
(at the work area protected by the L-shaped protective walls)

Air dose rate:
0.2–0.3 mSv/h
(Reduced to 1/5 – 1/6)

Implementation of the measure for radiation exposure reduction (2): 5-Block Areas

Reduction measure: installation of working platforms and RC shielding plates

Before the measure (radiation sources: slope, front building)

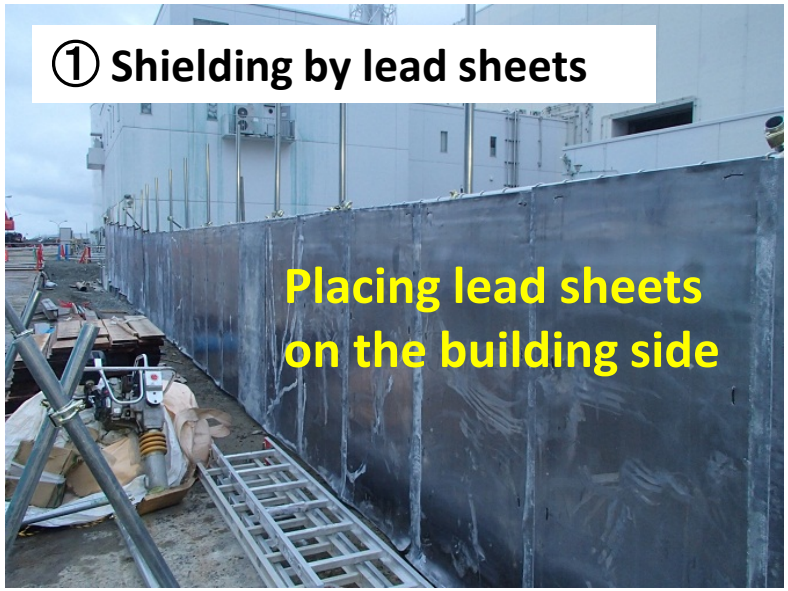
Air dose rate:
1.0–1.2 mSv/h

After the measure
(at the working platform)

Air dose rate:
0.3–0.5 mSv/h
(reduced to 1/3 – 1/4)

Implementation of the measure for radiation exposure reduction (3): 11-Block Areas

▪ Example of reduction measures



Evaluation for each exposure reduction measure (example of earthwork)

■Break down of earthwork

	Break down of earthwork	Input until May (man·day)	Ratio
①	Exposure reduction measures	21,165	20%
②	Installation of trench	20,107	19%
③	Excavation/earthwork	19,049	18%
④	Platform setting	8,466	8%
⑤	Residual soil of plant work	6,350	6%
⑥	Protection of piping	6,350	6%
⑦	Temporary construction (water supply, etc.)	3,175	3%
⑧	Recharge	7,408	7%
⑨	Freezing plant	13,757	13%
	Total	105,825	100%

・Earth work (trade-off of exposure dose until May)

Trade-off of the exposure reduction work		Total no. of workers	Increased exposure dose	Total exposure dose
		man·day	mSv/man/day	Man-mSv
①	Exposure reduction work	21,165	—	3,474
Σ②:⑨	Earthwork	84,660	0.12	-10,159
		Trade-off of exposure dose		-6,685

Evaluation for each exposure reduction measure (borehole drilling)

■Break down of the borehole drilling

	Break down of earthwork	Total input until May (man·day)	Ratio
①	Drilling boreholes	23,448	34%
②	Connecting pipes	14,482	21%
③	Piping	8,276	12%
④	Additional borehole drilling	4,827	7%
⑤	Penetration works	4,138	6%
⑥	Drilling stand pipes	13,793	20%
	Total	68,964	100%

Borehole drilling (trade-off of exposure dose until May)

Trade-off of the exposure reduction work		Total no. of workers	Increased exposure dose	Total exposure dose
		Man·day	mSv/man/day	Man·mSv
Σ①:⑥	Borehole drilling	68,964	0.13	-8,965
		Trade-off of exposure dose		-8,965

3. Reduction based on improvement of efficiency in construction methods

・Objective of improvement in efficiency

The improvement in work efficiency leads to reduction of work hours, resulting in reduction of exposure dose.

Exposure Eq.: a(mSv/h) × t(h) = at(mSv)

↑

Reduction of work hours

*** Even a small reduction in work hours, if repeated every day, could lead to a huge reduction in radiation exposure.**

Measures for improvement in work efficiency (1)

Amount of reduced exposure dose by trenches of precast concrete

Data for calculation		Values	Note
Dose rate (mSv/h)	a	0.12	・Roads closure takes place only during drilling works as it takes one night for installation of trenches of precast concrete. ・Installation of trenches of precast concrete (taking one day) realizes the reduction of the total exposure dose worthy of four days because in the case of all works conducted at the site it takes a total of five days of works per one block, which consists of reinforcement works (two days), formwork (two days), and concrete placement (one day).
Work hours (h)	b	3.0	
Construction length (m)	c	540	
No. of workers (man/day)	d	40	
Rate (m/Blk)	e	6.0	
Additional days per Blk (day/Blk)	f	4	
No. of blocks (Blk)	g = c/e	90	
Reduced amt. of exp. dose (man-mSv)		Eq.: 0.12 mSv/h ×3 h×40 man/day×90 Blk×4 day/Blk＝	-5,184 Man·mSv

Measures for improvement in work efficiency (2)

Amount of reduced exposure dose by the development of joint jigs in borehole drilling pipes

Data for calculation		Values	Note		
Dose rate (mSv/h)	a	0.13	・Reduction attempted of work hours by mechanically connecting borehole drilling pipes, which was formerly conducted by human works. ・Reduction of work hours effective for sea side roadworks due to installation/removal being conducted every night. (Reduction of work hours per one pipe) ・By humans: 5 min/joint, by machines: 4 min/joint ・No. of joints: 20/hole; Reduction of hours: (5 - 4) min × 20＝20 min/hole		
Reduction of hours (min/hole)	b	20			
No. of workers (man/day)	d	200			
No. of drilled holes	c	1800			
Rate (hole/day)	e	6			
Reduced amt. of exp.dose (man-mSv)		Eq.: 0.13 mSv/h × 20/60 h × 200 man/day × 1800 ÷ 6/day＝		-2,600	Man·mSv

Developed joint jigs for pipes

Measures for improvement in work efficiency (3)

Amount of reduced exposure dose by automated welding of freezing pipes

Data for calculation		Values	Note
Dose rate (mSv/h)	a	0.13	・Reduction of work hours, attempted by automated welding for connecting freezing pipes.
Reduction of hours (min/pipe)	b	20	
Number of workers (man/day)	d	100	
No. of pipes	c	1500	(reduction of work hours per one freezing pipe)
Rate (pipe/day)	e	8	・Welding by humans: 30 min/joint; automated welding: 20 min/joint
			・No. of joints: 2 joints/pipe; reduction of hours: (30 min - 20 min) ×2 = 20 min/pipe
Reduced amt. of exp. rate (man·mSv)		Eq.: 0.13 mSv/h × 20/60 h × 100 man/day × 1500 ÷ 8/day =	-813 Man·mSv

Measures for improvement in work efficiency (4)

Amount of reduced exposure dose by switching the drilling method to coring

Data for calculation		Values	Note
Dose rate (mSv/h)	a	0.13	・Switching the drilling method from boring (rotary drilling) to coring has achieved reduction in work hours owing to reduction in time for installation/removal and moving of a drilling machine from one drilling point to another. (Reduction of work hours per one day) ・Installation/removal of a rotary drill: 60 min ・Installation/removal of a core drill: 20 min ・Moving b/w drilling points: rotary drill (20 min/point), Core drill (10 min/point) ・Reduction of hours: (60－20)＋ (20－10)×2 points ＝ 60 min/day
Reduction of hours (min/day)	b	60	
No. of workers (man/day)	d	30	
No. of drilled holes	c	150	
Rate (hole/day)	e	3	
Reduced amt. of exp. rate (man·mSv)		Eq.: 0.13 mSv/h × 60/60 h × 30 man/day × 150 ÷ 3/day＝	-195 Man·mSv

4. Evaluation of reduction of total exposure dose

Evaluation of reduction in total exposure dose

- **Total exposure dose without measures for exposure reduction (actual + prediction)**

  Exposure dose during the main works* ② : 36,574 mSv
  Increased exposure dose ④ : 31,314 mSv (= ⑤ + ⑥)
  Total : 67,888 mSv

  * Works for construction of the land-side impermeable walls using the frozen soil method

- **Exposure dose when implementing the measures ③ (actual + prediction) : 3,905 mSv**

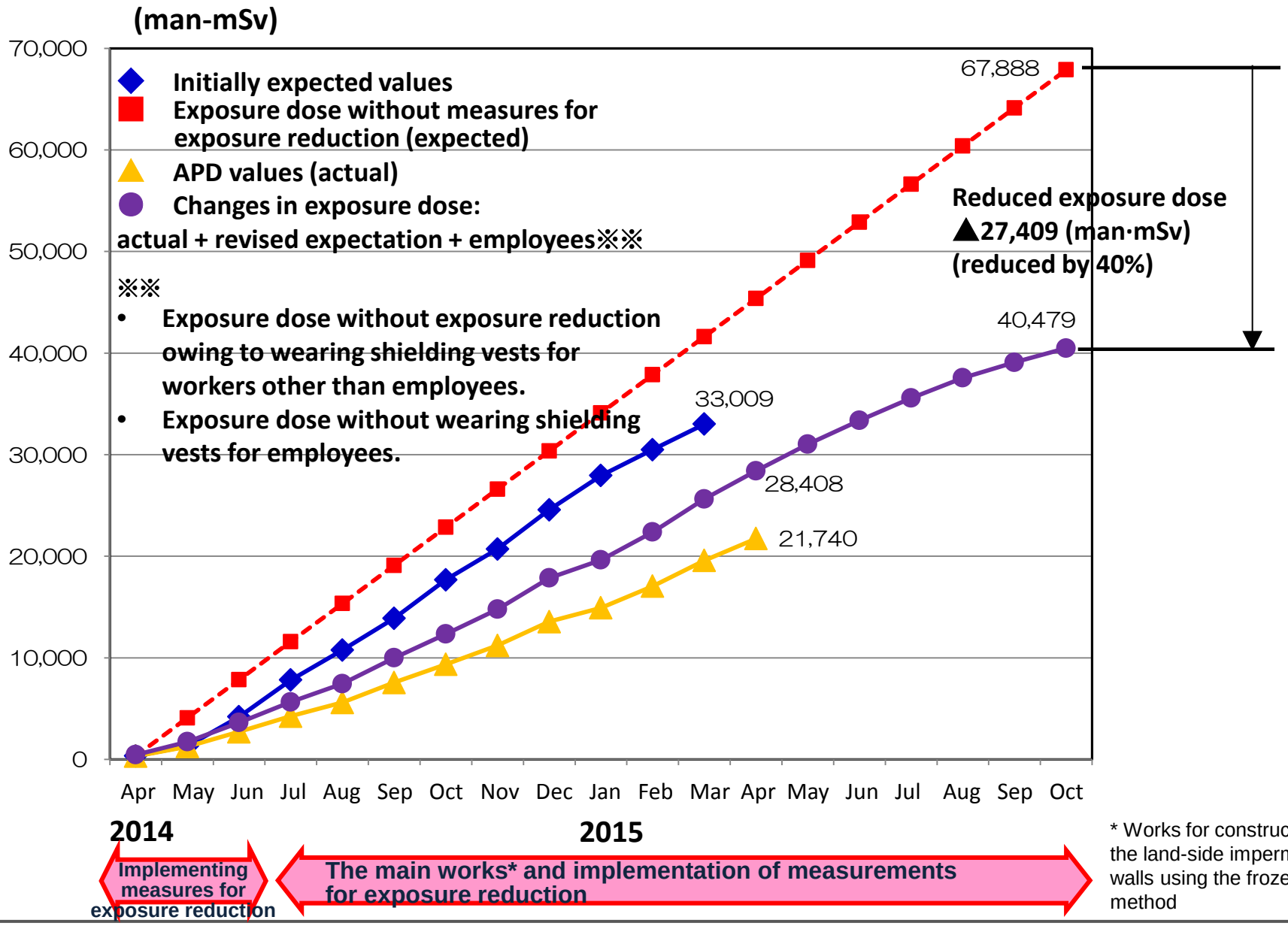
- **Trade-off of exposure dose between the cases with and without measures**

  Exposure dose when implementing the measures vs. Exposure dose without the measures
  = ③ vs. ④ = 3,905 vs. 31,314 ⇒ ▲27,409 mSv

Unit: man·mSv

Total exposure (actual + prediction) ①		Exposure dose without the measures for exposure reduction ④			
		Amount of exposure reduction owing to improvement of work efficiency ⑤		Increased exposure doses ⑥	
Exposure dose during the main works ②	36,574	Adoption of trenches of precast concrete	5,184	Earthwork (until May 2015)	10,159
Measures for exposure reduction③	3,905	Joint jigs for borehole drill pipes	2,600	Earthwork (since June 2015)	1,616
		Automated welding of freezing pipes	813	Borehole drilling (until May 2015)	8,965
		Coring for penetration points	195	Borehole drilling (since June 2015)	1,782
		⑤ Sub-total	8,792	⑥Sub-total	22,522
①＝②＋③	40,479			④＝⑤＋⑥	31,314

Evaluation of reduction in total exposure dose



* Works for construction of the land-side impermeable walls using the frozen soil method

5. Education of new workers

Training in wearing protective equipment (for new workers)

Full face mask

Coverall (white Tyvek)

Anorak (works during rain or handling water)

Shielding vest (weighing 6 kg)