Current state and new technologies for CSO control in Japan

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1. Introduction
The combined sewer system (CSS) was adopted by 191 cities, which were pioneering municipalities in developing the sewer system. Most CSS users are concentrated in the major cities. CSS now accounts for about 20% of the national land area covered by sewer networks and about 30% of the national population served by sewer networks. However, this system allows untreated sewage to be discharged to public water bodies during rainfall, and so has become a serious issue for years in terms of water quality, public hygiene, and the environment. For example, a large amount of oil balls washed ashore on a beach at a waterfront park that features water-friendly landscaping at Odaiba, Tokyo, making front-page news in September 2000. As a result, the combined sewer overflow (CSO) become a serious social problem. In response, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) set up the Combined Sewer System Improvement Committee composed of experts, local governments, and related organizations the following year to discuss and formulate basic measures for improving CSS.

2. Current Status of the Combined Sewer Overflow of the Combined Sewer System
The Combined Sewer System Improvement Committee (“CSSI Committee”) conducted a field survey of CSS for the entire country and gathered data on storm outfalls and overflow during rainfall. The data revealed there are as many as 2,420 natural outfalls, 544 outfalls leading from pump stations, and 670 natural outfalls whose intercepted rainfall sewage is less than 1 mm/hr. Discharged water quality is also poor. At some points, a maximum BOD of 1,310 mg/l and coliform count of 1,600,000 ml were recorded. From these research results, the CSSI Committee established the following targets to be achieved in roughly 10 years:

1) Reduction in pollution load: The target pollution load should be equal to or lower than the pollution load expected to occur in case the combined sewer system is replaced by the separate sewer system.
2) Assurance of public hygiene and safety: The number of untreated discharges from all

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outfalls should be at least halved. 

(3) Reduction in impurities: Release of impurities should be minimized at all outfalls.

3. Challenges and New Technological Development

Since measures to improve CSS must cope with a large amount of sewage that occurs temporarily and variably, the measures are quite different from those for dealing with sewage treatment on sunny days. Measures taken to improve CSS so far include reinforcing stormwater reservoirs and intercepting sewers, but improving stormwater reservoirs can be expensive depending on the location, and even if the amount of intercepted sewage is increased, it may not be possible to treat the increased amount at existing sewage plants. Private companies are developing technologies to overcome these problems, but there has been no framework to comprehensively evaluate the performance of such technologies. Therefore, the MLIT set up a new technical development project, SPRIT21 (Sewage Project, Integrated and Revolutionary Technology for the 21st Century), to comprehensively evaluate private firms' new technologies and to encourage rapid commercialization of a variety of new technologies. The MLIT started by identifying technologies related to improvement of the combined sewer system. SPRIT21 will publicly solicit private companies to participate in field research for technological development, particularly for sewer systems, and will examine and evaluate the performance of the proposed technologies at an examination committee consisting of experts, local governments and related organizations.

4. Outline of New Techniques

In response to the public solicitation, 24 techniques were proposed, all of which were confirmed to satisfy all the performance requirements. Those techniques evaluated in the SPRIT21 project are outlined below:

(1) Removal of impurities

Several techniques have been proposed for removing impurities emitted from natural outfalls or pump stations, including brush type, multi-porous disk type, disk type, and bar screen (lateral arrangement) type. Each of these has a mechanism to rake out impurities captured by the screen. The raking mechanism is powered in various ways: by water wheels driven by overflow, power generated by an electric motor, and hydraulic power.

(2) High-speed filtering technique

This technique reduces pollution loads off from the overflow from the pump station and the primarily treated water from the sewage plant. The proposed techniques may be installed by remodeling the initial settling tank of the plant. Since the technique basically needs to treat a large amount of water in a compact size, the proposed techniques incorporate various ways to improve filtering speed such as using synthetic fibers with a large porosity rate or special filtering materials made of molded synthetic resins to reduce the resistance of water as it passes through the filter bed or to capture pollutants in the entire filter bed.

(3) Coagulation and separation technique
This technique reduces pollution loads off from the overflow from the pump station and the primarily treated water from the sewage plant. Like the high-speed filtering technique, the proposed coagulation and separation techniques may also be installed by remodeling the initial settling tank of the plant. In general, chemical precipitation requires a large settling basin, but the proposed ones feature various processes such as using particulate sand to form coagulated flocks that have a high settling speed or using a swirling separation tank equipped with special screen that can separate flocks very rapidly to ensure swift precipitation and separation and make the equipment smaller.

(4) Sterilization technique
To reduce the impact on the water body to which the water is discharged, some of the proposed sterilization techniques use a special method to add disinfectants (mixed agitation method) to improve sterilization efficiency, while others use bromine chemicals, high-concentration ozone, or ultraviolet light to perform rapid disinfection.

(5) Measurement and control technique
There are two main measurement and control techniques: one is automatic coliform count measurement equipment that reduces the analysis time and controls the feeding volume of chlorine, and the other is an ultraviolet ray absorption spectrometer that automatically monitors organic concentration or SS.

5. Conclusion
Many cities that use CCS reviewed the use or construction of facilities to solve the problems related to CCS, but most of them are failing to progress with the plans as scheduled: about 40% of the plans are not progressing as planned, with cities citing financial issues as the major reason for the delay. In response, MLIT set up a subsidiary scheme to help them formulate countermeasures and construct facilities for improvement and is encouraging the cities to implement the plan as early as possible. The cities are now reviewing their plans for more efficient execution by using the techniques introduced in this paper.
1. Introduction

191 cities all over Japan have introduced the combined sewer system.

About 20% of the area covered by the sewer system

About 30% of the population served by the sewer system
Many oil balls washed ashore at Odaiba marine park in September 2000.

- The incident made the headlines and became a public issue.

The Ministry of Land, Infrastructure, Transport and Tourism set up the Combined Sewer System Improvement Measures Review Committee composed of experts, local governments and related organizations.

2. Current Status of CSO

- Natural outfalls: 2,420
- Pumping stations: 544
- Locations with less than 1 mm/hr intercepted rainfall sewage: 670

<table>
<thead>
<tr>
<th>Type of facility</th>
<th>Water quality range</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewage plant</td>
<td>BOD 10 – 251 mg/l</td>
<td>Interception rate: 3 times</td>
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<tr>
<td></td>
<td>SS 12 – 348 mg/l</td>
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<tr>
<td></td>
<td>COD 4.1 – 165 mg/l</td>
<td></td>
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<tr>
<td>Pump station</td>
<td>BOD 3 – 330 mg/l</td>
<td>Intercepted rainfall sewage: 0.7 to 4.8 mm/hr</td>
</tr>
<tr>
<td></td>
<td>SS 3 – 160 mg/l</td>
<td></td>
</tr>
<tr>
<td></td>
<td>COD 11 – 810 mg/l</td>
<td></td>
</tr>
<tr>
<td>Storm outfall</td>
<td>BOD 5 – 1,310 mg/l</td>
<td>Intercepted rainfall sewage: 1.0 to 4.2 mm/hr</td>
</tr>
<tr>
<td></td>
<td>SS 7 – 445 mg/l</td>
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</tr>
<tr>
<td></td>
<td>COD 11 – 1,440 mg/l</td>
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<tr>
<td></td>
<td>Coliform count 160 – 500,000 /ml</td>
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</tr>
</tbody>
</table>

- BOD (maximum): 1,310 mg/l
- Coliform count (maximum): 1,600,000/ml
3. Goals of the Combined Sewer System Improvement

(1) Reduction in pollution loads
The pollution load of the combined sewer system should be reduced to the same level as or lower than the pollution load expected to occur if the combined sewer system was replaced by the separate sewer system.

(2) Safety assurance of public sanitation
The number of releases of untreated sewage should be at least halved for all outfalls.

(3) Removal of grit
Outflow of grit should be minimized for all outfalls.

4. Tasks for Improvement

(1) Treatment of a large and varying amount of sewage is necessary.

(2) A large area is necessary for a stormwater reservoir for pollution control.

(3) Existing treatment plants cannot handle sewage even if additional intercepting sewers are installed.
• New techniques should be developed to address those tasks.
• Private corporations are commercializing new techniques.
• A framework for comprehensively evaluating techniques is necessary.

➔ A new technological development project of experts, local governments and relevant organizations was launched: SPIRIT 21.
5. Framework to new technological development

SPIRIT Committee
- Selection of technological development
- Public solicitation for participating researchers
- Selection of participating researchers
- Examination of and advice on research plans
- Examination and technical evaluation of research results
- Reflection in measures

Private companies
- Private companies replying to the offer
- Formulation of research plans
- Execution of research

Joint research

6. Techniques Solicited from the Public and Development Targets

(1) Removal of grit
   The new technique should improve removal of grit by over 30%.

(2) Removal of pollutants
   The new technique should remove >30% of pollution in terms of BOD and SS.

(3) Disinfection
   • Coliform count <3,000 per ml
   • Reaction time and genetic toxicity equivalent to the existing technique
   • Affordable running cost

(4) Measurement and control
   • The new technique should be able to accurately and continuously measure water quality.
### 7. List of CSO control technologies

<table>
<thead>
<tr>
<th>Technology category</th>
<th>No.</th>
<th>Technology</th>
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</thead>
<tbody>
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<td>Debris Removal (Screen)</td>
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<tr>
<td></td>
<td>1</td>
<td>Hydroclean Brush Screen</td>
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<td></td>
<td>2</td>
<td>Rotamat RMK1 Screen</td>
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<td></td>
<td>3</td>
<td>CSO Screen</td>
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<td>Disc Screen</td>
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<td>5</td>
<td>Storm Screen</td>
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<td>6</td>
<td>Ultra Fine Screen using perforated panel with tapered holes</td>
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<td>7</td>
<td>The Copa Raked Bar Screen</td>
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<td></td>
<td>8</td>
<td>Rotary Screen</td>
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<tr>
<td>High Rate Filtration</td>
<td>9</td>
<td>Wet-weather high-speed wastewater filtration system</td>
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<tr>
<td></td>
<td>10</td>
<td>High-Rate Filtration with a Synthetic Media</td>
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<td>11</td>
<td>CDS Screen and the high-rate filtration method using specially-processed fibers of a material.</td>
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<td></td>
<td>12</td>
<td>Super-High-Speed Fiber Filtration for Untreated Combined Sewage Water Overflow on Rainy Days</td>
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<td></td>
<td>13</td>
<td>High Rate Filtration Process</td>
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<td>Coagulation / Separation</td>
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<td>ACTIFLO PROCESS</td>
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<td>15</td>
<td>High Rate Coagulation System using CDS Screen (FSS System)</td>
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<tr>
<td>Disinfection</td>
<td>16</td>
<td>Effective disinfection system with chlorine dioxide</td>
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<td></td>
<td>17</td>
<td>CSO DISINFECTION SYSTEM BY MEDIUM-PRESSURE UV LAMPS</td>
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<td></td>
<td>18</td>
<td>Rapid Disinfection of Combined Sewer Overflow using Chlorine Dioxide</td>
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<td>19</td>
<td>Rapid Disinfection Technique Using High Concentration Ozone for Combined Sewer Overflow</td>
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<td>20</td>
<td>BCDMH Disinfection</td>
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<td></td>
<td>21</td>
<td>The economical ozone disinfection system by using ozone adsorbing technology</td>
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<tr>
<td></td>
<td>22</td>
<td>Ultraviolet disinfection system</td>
</tr>
<tr>
<td>Measurement / Control</td>
<td>23</td>
<td>Organic pollutant monitor (UV meter)</td>
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<tr>
<td></td>
<td>24</td>
<td>Automatic coliform counter</td>
</tr>
</tbody>
</table>

#### (1) Removal of impurities

[Diagram of debris removal (Rotamat RMK1 Screen)]
(2) Removal of pollutants: High-speed filtering technique

Wet-weather high-speed wastewater filtration system
(3) Removal of pollutants: Coagulation and separation technique
(4) Disinfection technique

Effective disinfection system with chlorine dioxide
(5) Measurement and control technique

Organic pollutant monitor (UV meter)
8. Conclusion

- New techniques for combined sewage systems have been developed.
- Improvement measurement programs are being reviewed at many cities to incorporate the new techniques in practice.
- For details of each technique, please visit: http://www.jiwet.or.jp/