GSRDs: Phase I

Phase I
Gross Solids Removal Devices Pilot Study: 2000 - 2002

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Acronyms, Abbreviations and Units

Acronyms and Abbreviations

BMP	Best Management Practice
Caltrans	California Department of Transportation
FRP	Fiberglass Reinforced Plastic
GLAVCD	Greater Los Angeles County Vector Control District
GSRD	Gross Solids Removal Device
LA RWQCB	Los Angeles Regional Water Quality Control Board
LSRD	Litter Solids Removal Device
RWQCB	Regional Water Quality Control Board
SGVMVCD	San Gabriel Valley Mosquito and Vector Control District
SWMP	Caltrans Statewide Storm Water Management Plan
TMDLs	Total Maximum Daily Loads
WLA	Waste Load Allocation
BB I-405	I-405 at Leadwell: Baffle Box
BB I-210	I-210 at Christy: Baffle Box
IS1 SR-170	SR-170 at KP 26.1: Inclined Screen – Configuration #1
IS2 I-210	I-210 at Orcas: Inclined Screen – Configuration #2
IS2 US-101	US-101 at Gaviota: Inclined Screen – Configuration #2
LR1 I-10	I-10 at Rosemead: Linear Radial – Configuration #1
LR2 I-210	I-210 at Glenada: Linear Radial – Configuration #2
LR2 I-5	I-5 at Garber: Linear Radial – Configuration #2

Units

ac	Acre
ft	Feet
ft^3	Cubic feet
ft^3/ac	Cubic feet per acre
ha	Hectare
in	Inch
kg	Kilogram
kg/ha	Kilograms per hectare
KP	Kilometer Post
lb	Pounds
lb/ac	Pounds per acre
m	Meter
mm	Millimeter
m^3	Cubic meter
m^3/ha	Cubic meters per hectare
PM	Post Mile
UV	Ultraviolet

Executive Summary

The objective of the Phase I Gross Solids Removal Devices (GSRDs) Pilot Study was to evaluate the performance of non-proprietary devices that can capture gross solids and can be implemented into highway drainage systems. The term "gross solids" includes litter, vegetation, and other particles of relatively large size.

Three design concepts developed for this pilot study were the Linear Radial, the Inclined Screen, and the Baffle Box. The Linear Radial – Configuration #1 GSRD utilizes a modular well casing with louvers to serve as the screen. The Linear Radial – Configuration #2 GSRD utilizes a rigid mesh screen housing with nylon mesh bags that capture gross solids. The Inclined Screen – Configuration #1 GSRD utilizes parabolic wedge-wire screen to screen out gross solids. The Inclined Screen – Configuration #2 GSRD utilizes parabolic bars to screen out gross solids. The Baffle Box applies a two-chamber concept: the first chamber utilizes an underflow weir to trap floatable gross solids, and the second chamber uses a bar rack to capture materials that get past the underflow weir. Installation costs for the pilot devices, not including monitoring equipment, ranged from $32,200 per hectare ($13,054 per acre) to $235,970 per hectare ($104,876 per acre). Variability in cost was due to site-specific requirements that included unidentified underground utilities, extensive site excavation, grading, and site vegetation.

Following a targeted storm event, each GSRD was visually inspected and assessed for screen clogging, proper drainage, and material accumulation. During each cleaning procedure, the weight and volume of gross solids removed from the device, bypass bag, and overflow basket (if applicable), were measured. The performance of each GSRD was assessed by evaluating how well the GSRD met the design objectives: the criteria set by the TMDL, and criteria and goals set by Caltrans. The criteria and goals applied to the study are listed below.

	Criteria (C) or Goal (G)		Description
TMDL Criteria	C1	Particle Capture	The device or system must capture all particles retained by a 5 mm (0.2 in nominal) mesh screen from all runoff generated from a one-year, one-hour storm (determined to be 0.6 in (15 mm) per hour for the Los Angeles River Watershed).
	C2	Clogging	The device or system must be designed to prevent plugging or blockage of the screening module.
Caltrans Criteria	C3	Hydraulic Capacity	The device or system must pass the Caltrans design flow. In District 7, this design flow is the 25-year peak flow.
	C4	Drainage	The device or system must drain within 72 hours to avoid vector breeding.
Caltrans Goal	G1	Gross Solids Storage Capacity	The device or system will hold the estimated annual load of gross solids, so that it requires only one cleaning per year.
	G2	Maintenance Requirements	The device or system will not require any maintenance other than inspections throughout the storm season.

Of the five configurations tested, the most promising devices, based on considerations of particle capture, clogging, passing design flow, drainage, stage capacity, and maintenance requirements, were the Linear Radial – Configuration #1 (louvered modular well casing), and the Inclined Screen – Configuration #1 (parabolic wedge-wire screen). These two devices meet the definition of a full capture treatment system.

Section 1
Introduction and Study Design

1.1 OBJECTIVE

The Gross Solids Removal Devices (GSRDs) Pilot Program (Program) was initiated by the California Department of Transportation (Caltrans) to develop and evaluate the performance of non-proprietary devices that can capture gross solids and be retrofitted into existing highway drainage systems or implemented in future highway drainage systems. The term "gross solids" includes litter, vegetation, and other particles of relatively large size. The Caltrans *Guidance for Monitoring Storm Water Litter* (Caltrans, 2000) defines litter, consistent with the definition of the TMDL, as "manufactured items made from paper, plastic, cardboard, glass, metal, etc. that can be retained by a 5 mm (0.2 in nominal) mesh screen."

1.2 BACKGROUND

Total Maximum Daily Loads (TMDLs) for trash in the Los Angeles River Watershed and the Ballona Creek Watershed have been adopted in Southern California. The requirements of these two TMDLs are discussed further in Sections 2 and 6. The non-proprietary devices developed and evaluated in the Program may be selected to meet the requirements of these two TMDLs.

The Program consists of multiple phases with each phase representing one pilot study. A pilot study consists of one or more devices that have: developed from concept; advanced through design and installation; and, conducted two years of pilot testing for overall performance. Each pilot study consists of the following four general tasks:

- Task 1 - Concept Development
- Task 2 - Scoping, Preliminary Design, and Site Selection
- Task 3 - Final Design, Bidding, and Implementation
- Task 4 - Monitoring, Performance Assessment, and Refinement

The first pilot study in the Program is the Phase I GSRDs Pilot Study. Task 1 took place between January and April 2000. Task 2 took place between April and August 2000. Task 3 took place between August and December 2000. Task 4 took place between December 2000 and June 2002.

At the time this report was prepared, the Program included five pilot studies or phases. Each phase studies different non-proprietary devices. This report only covers Phase I. Figure 1-1 presents a timeline for monitoring of the five pilot studies. The Phase II GSRDs Pilot Study, consisting of one device, has completed monitoring and the final report is under preparation. The Phase III GSRDs Pilot Study, consisting of three devices, has completed the first year of monitoring with one more year remaining. The Phase IV GSRDs Pilot Study has finished design and is awaiting installation. The Phase V GSRDs Pilot Study is currently in design.

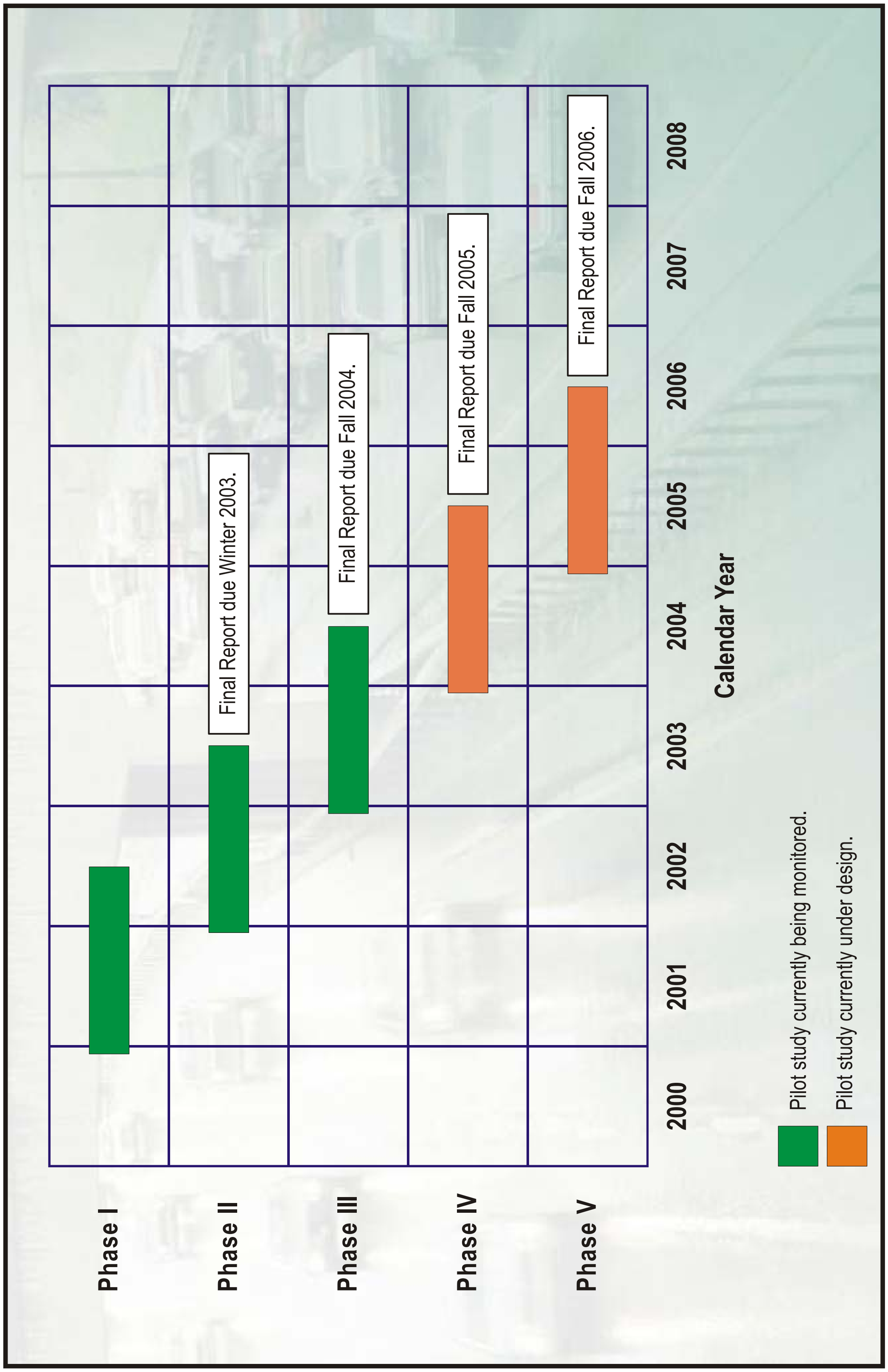


Figure 1-1
Monitoring Schedule for GSRD Pilot Studies

Between the planning stage of the study and preparation of this final report, the study name has changed. Initially, the study was referred to as the "Litter Solids Removal Device Pilot Study." Additionally, the devices in the study were referred to as "Litter Solids Removal Devices" or "LSRDs." A few documents that are referenced in this final report refer to this initial study name and to the devices as LSRDs. The study name changed to "Phase I Gross Solids Removal Devices Pilot Study", and the devices were renamed as "Gross Solids Removal Devices" or "GSRDs." As a result, LSRDs and GSRDs refer to the same type of devices. The name change was initiated for two reasons. The term "gross solids" was selected to better describe both the litter and the vegetative material that these devices target for capture. "Phase I" was added for the activities described through the end of the 2001-02 season to imply that additional pilot studies are now being conducted to evaluate additional GSRDs.

1.3 TERMINOLOGY

The following terminology is used in this report and is defined as follows:

- Downstream Bypass Bag – Nylon mesh bag with 5 mm (0.2 in nominal) opening connected to the end of the downstream pipe, which collects gross solids that pass through the screen. Bypass bags apply to all of the GSRDs except for the Linear Radial type devices.

- Overflow/Bypass Bag – Nylon mesh bag with 5 mm (0.2 in nominal) opening connected to the end of the downstream pipe, which collects gross solids that bypass the screen and overflow structure. Overflow/Bypass Bags apply only to the Linear Radial type devices.

- Overflow Basket – Metal basket that captures gross solids that overtop the overflow weir. Overflow baskets are not applicable to all GSRDs.

- Overflow Condition – Condition which occurs when the water level reaches beyond the maximum level in the device, and inflow overtops the device. Under overflow conditions, most gross solids are captured in the overflow basket, where applicable, but some solids may escape the overflow basket and are left unaccounted for. Overflow conditions can occur when 1) inflow exceeds the capacity of the GSRD screen, 2) the screen is blinded, or 3) the outflow drains are plugged.

- Wet Weight – Weight of the gross solids without additional drying in the laboratory (as-collected weight of gross solids). Prior to transferring the gross solids to plastic trash bags, the solids are gravity drained for at least two minutes or until they are substantially drained of free water (e.g., no drips for 5 to 10 seconds).

- Wet Volume – Volume of the gross solids without drying in the laboratory (as-collected volume of gross solids). Prior to transferring the gross solids to plastic trash bags, the solids are gravity drained for at least two minutes or until they are substantially drained of free water (e.g., no drips for 5 to 10 seconds).

- Air-Dried Weight – Weight of the gross solids after drying in the laboratory.

- Air-Dried Volume – Volume of the gross solids after dying in the laboratory.

1.4 REPORT ORGANIZATION

This report is organized as follows:

- **Section 1** presents the study objectives and background.
- **Section 2** presents the concept development and design criteria.
- **Section 3** summarizes the site selection, implementation details, and installation costs at each site.
- **Section 4** summarizes the monitoring procedures. A discussion of operations including the event summaries for each monitoring location and general GSRD performance during the 2000-01 and 2001-02 monitoring seasons is also presented.
- **Section 5** presents the gross solids data collected during the 2000-01 and 2001-02 monitoring seasons.
- **Section 6** presents a summary of the overall performance of each GSRD during the 2000-01 and 2001-02 monitoring seasons.
- **Section 7** presents references cited in this report.

1.5 S.I. AND U.S. CUSTOMARY UNITS

This report provides units in both Standard International (S.I.) units and United States (U.S.) Customary units. In general, measurements and calculations are performed in S.I. units and converted to U.S. Customary units for reporting. Additionally, nominal dimensions of pipe diameters are provided, consistent with International Standards Organization (ISO) usage. For example, a 24 in pipe is referred to as a 600 mm pipe.

Section 2
Concept Development

2.1 DESIGN OBJECTIVES

The Phase I GSRDs Pilot Study was designed to meet the criteria set by the TMDL for trash in the Los Angeles River Watershed and the criteria and goals set by Caltrans. The six design objectives listed below represent criteria and goals applied to the GSRDs. For this pilot study, meeting criteria held a higher importance than meeting goals.

The following two criteria were set by the TMDL for an approved full capture treatment system:

- The device or system will capture all particles retained by a 5 mm (0.2 in nominal) mesh screen from all runoff generated from a one-year, one-hour storm (determined to be 0.6 in [15 mm] per hour for the Los Angeles River Watershed).
- The device or system is designed to prevent plugging or blockage of the screening module.

The following two criteria were set by Caltrans for a GSRD:

- The device or system will pass the design flow as specified in the Caltrans Highway Design Manual (Table 831.3). For this pilot study, the design flow is the 25-year peak flow.
- The device or system will drain within 72 hours to avoid vector breeding.

Additionally, the following two goals were set by Caltrans for a GSRD:

- The device or system will hold the estimated annual load of gross solids, resulting in one cleaning per year.
- The device or system will not require any maintenance other than inspections throughout the storm season.

The design objectives are discussed further in Section 6.

2.2 CONCEPTUAL DESIGN

The Phase I GSRDs Pilot Study was developed to test selected non-proprietary devices designed to remove gross solids from storm water runoff from highway facilities, both in new installation and in retrofit settings. The development of the conceptual designs is discussed below.

The initial conceptual design effort focused on the development of potential non-proprietary design concepts. During the conceptual design effort:

- Preliminary design criteria were identified based upon readily available information such as hydrology maps, as-built plans, and other information.

- Limited engineering was performed to estimate order-of-magnitude sizing and propose preliminary design criteria.
- Generic, non-site-specific design concepts were developed.
- Opportunities, feasibility issues, and constraints associated with each concept were identified.
- Initial concept design alternatives were presented to Caltrans' New Technology team for evaluation.

Three preliminary design concepts for different GSRDs were developed. These design concepts included the Linear Radial, the Inclined Screen, and the Baffle Box. The Linear Radial and Inclined Screen design concepts included two variations. Summaries of the design assumptions that underlie the concepts are presented in the following sections on a device-specific basis.

Several types of screens were investigated for use in this pilot study. They included:

- Rigid mesh screens
- Bi-wave wedge wire screens
- Louvered or slotted screens

The type of screen to be used for each GSRD was selected based on an evaluation by the design team considering what would perform best with respect to site conditions such as available footprint, slopes, hydraulic head, and other conditions. For example, all three screens potentially could be used for the Inclined Screen device with varying degrees of success but the wedge wire screens were expected to perform the best. Inclined wedge wire screens have exhibited proven performance in the food industry to separate solids from liquids. Due to the steep inclination of the screen, the Inclined Screen device could only be incorporated in sites which had sufficient hydraulic head.

2.2.1 Linear Radial – Configuration #1

This GSRD utilizes a modular well casing with 5 mm x 64 mm (0.2 in x 2.5 in nominal) louvers to serve as the screen (Figure 2-1). Flows are routed through the louvers and into a vault. Key design and operational concepts are as follows:

- Inflow is directed into the louvered screen contained within a concrete vault. The louvered screen and vault are linear and aligned parallel to the direction of flow.
- Flows pass radially through the louvered screen and into the vault.
- The louvered screen has a smooth, solid bottom section (extending 60 degrees) to facilitate the movement of settled gross solids toward the downstream end of the pipe.

- Sufficient screen area and volume are provided to accommodate the estimated annual volume of gross solids and to pass the required design storm.

- The vault can be configured with grates or covers, traffic or non-traffic rated, depending upon location within the highway right-of-way.

- The first section of pipe nearest the influent pipe has the same diameter as the louvered screen sections with an open top for emergency overflow. The overflow is designed to convey the Caltrans design flow and the opening has the same open cross sectional area as the pipe.

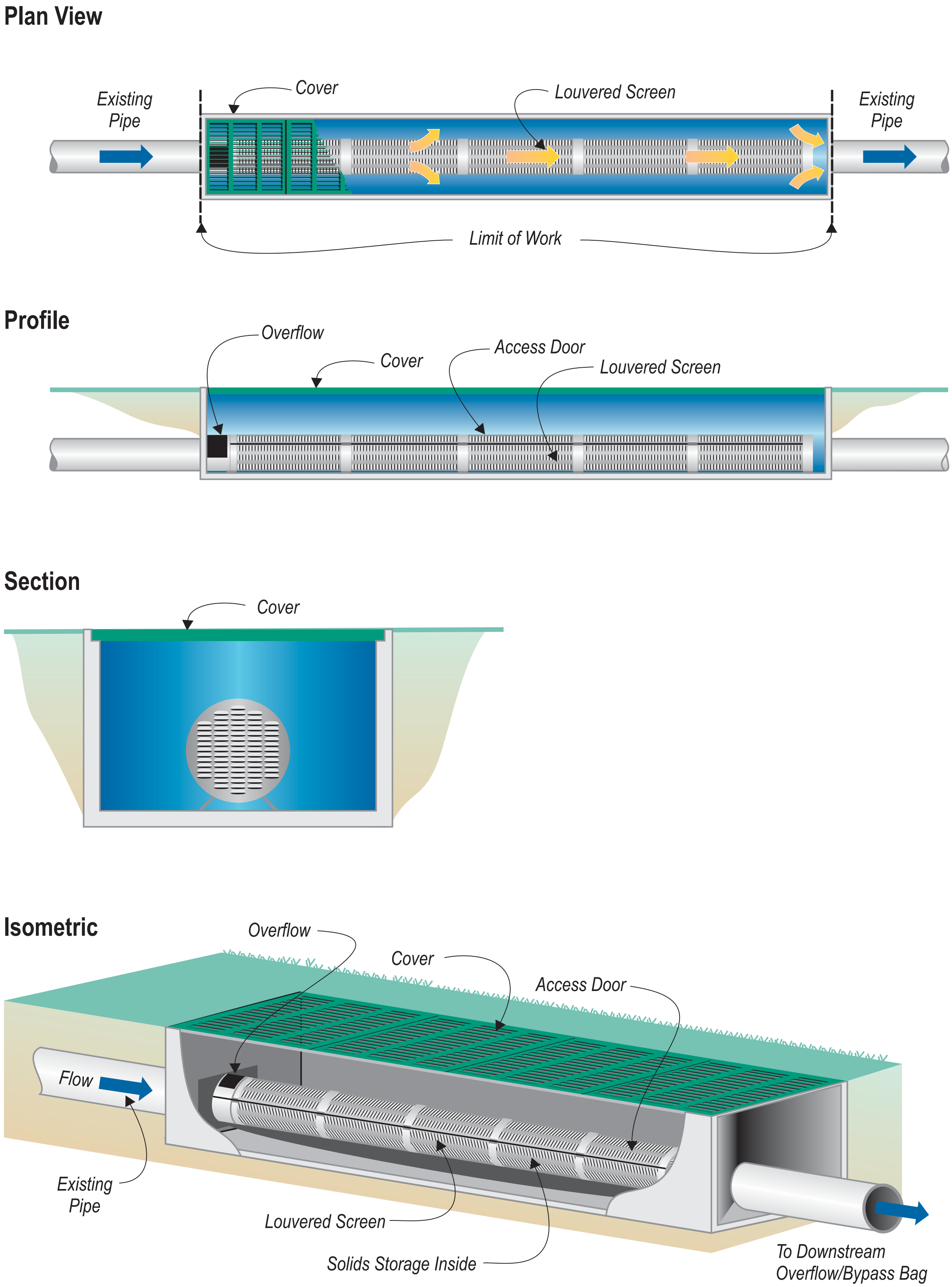


Figure 2-1
Concept Linear Radial Configuration #1

2.2.2 Linear Radial – Configuration #2

This GSRD utilizes a modular 5 mm x 5 mm (0.2 in x 0.2 in nominal) rigid mesh screen housing (Figure 2-2). Inside the rigid mesh screen are nylon mesh bags (5 mm [0.2 in] mesh) that capture gross solids. Flows are routed into the nylon mesh bags and exit into a vault. Key design and operational concepts are as follows:

- Inflow enters a mesh bag contained within the rigid mesh screen, which are both contained within a concrete vault. The screen and vault are linearly aligned and parallel to the direction of flow.
- The nylon mesh bags and rigid mesh screen provide sufficient area and volume to accommodate an estimated once per year cleaning without plugging.
- The vault can be configured with grates or covers, traffic or non-traffic rated, depending upon location within the highway right-of-way.
- The nylon mesh bags are placed inside the screen for ease of maintenance.
- In the case that the screens are plugged, storm water would flow over the screen housing to the outflow pipe.

2.2.3 Inclined Screen – Configuration #1

This GSRD uses a 3 mm (0.125 in nominal) spaced parabolic wedge-wire screen with the slotting perpendicular (horizontal orientation) to the direction of flow (Figure 2-3). The device is configured with an influent trough to allow some solids to settle. The flow then overtops a weir and falls through the inclined screen. After passing through the screen, the flow exits the GSRD. Gross solids are retained in a confined storage area that can be accessed by maintenance equipment. Key design and operational concepts are as follows:

- Inflow enters a trough to distribute flows along the length of the screen. The trough also provides an area of reduced velocity where larger solids can settle.
- The trough is drained by a series of weep holes. Sufficient weep holes are provided to drain the trough within 72 hours to prevent vector propagation.
- Flowing storm water pushes the gross solids. The gross solids are moved by gravity down the face of the screen to the gross solids storage area.
- The gross solids storage area is sloped and configured with a drain pipe and inlet grate to allow it to drain between storm events.
- The vault can be configured with grates or covers, traffic or non-traffic rated, depending upon location within the highway right-of-way.
- In the case that the screens are completely plugged, storm water would overflow the entire device to the downstream receiving waters.

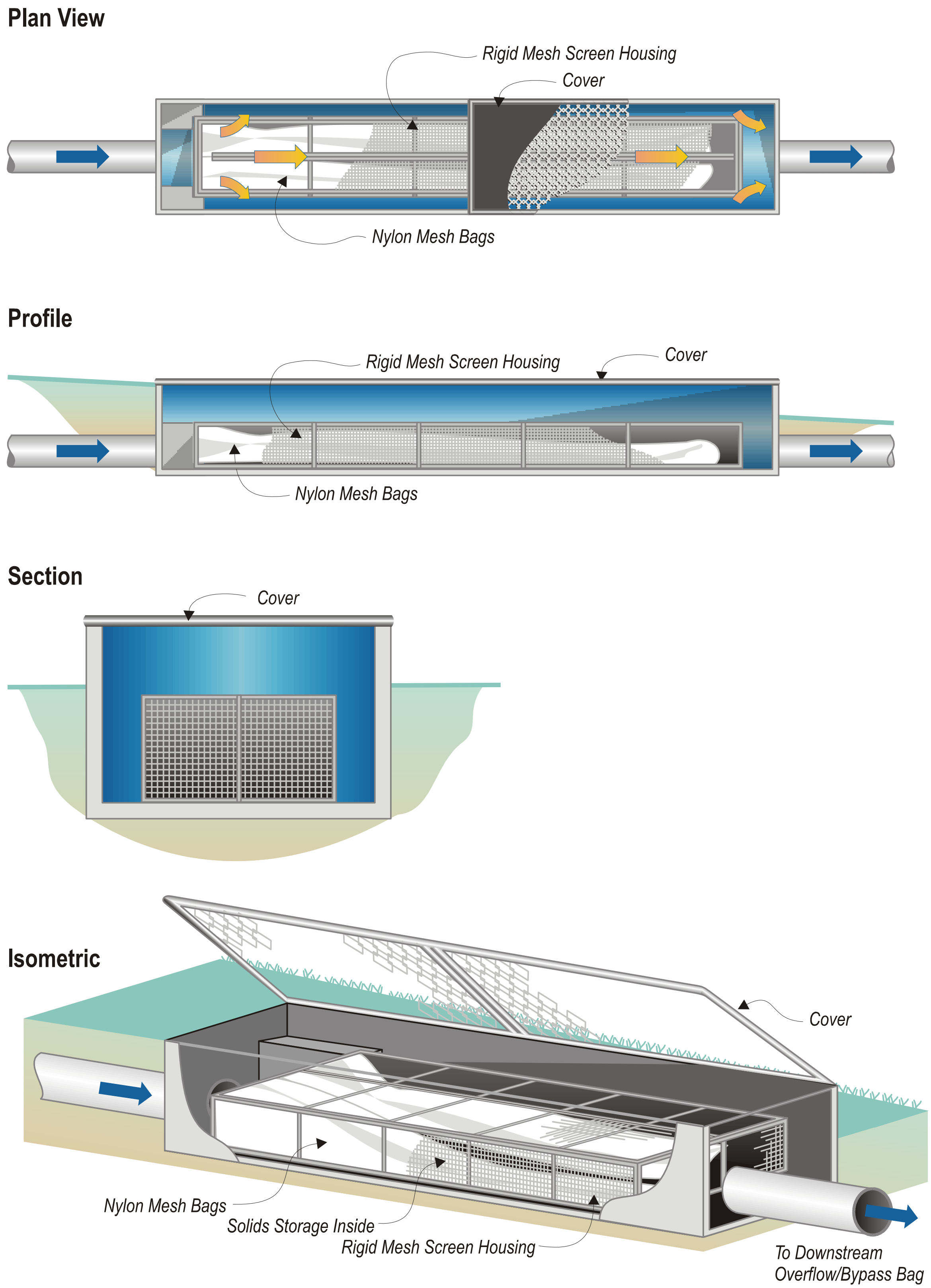


Figure 2-2
Concept Linear Radial Configuration #2

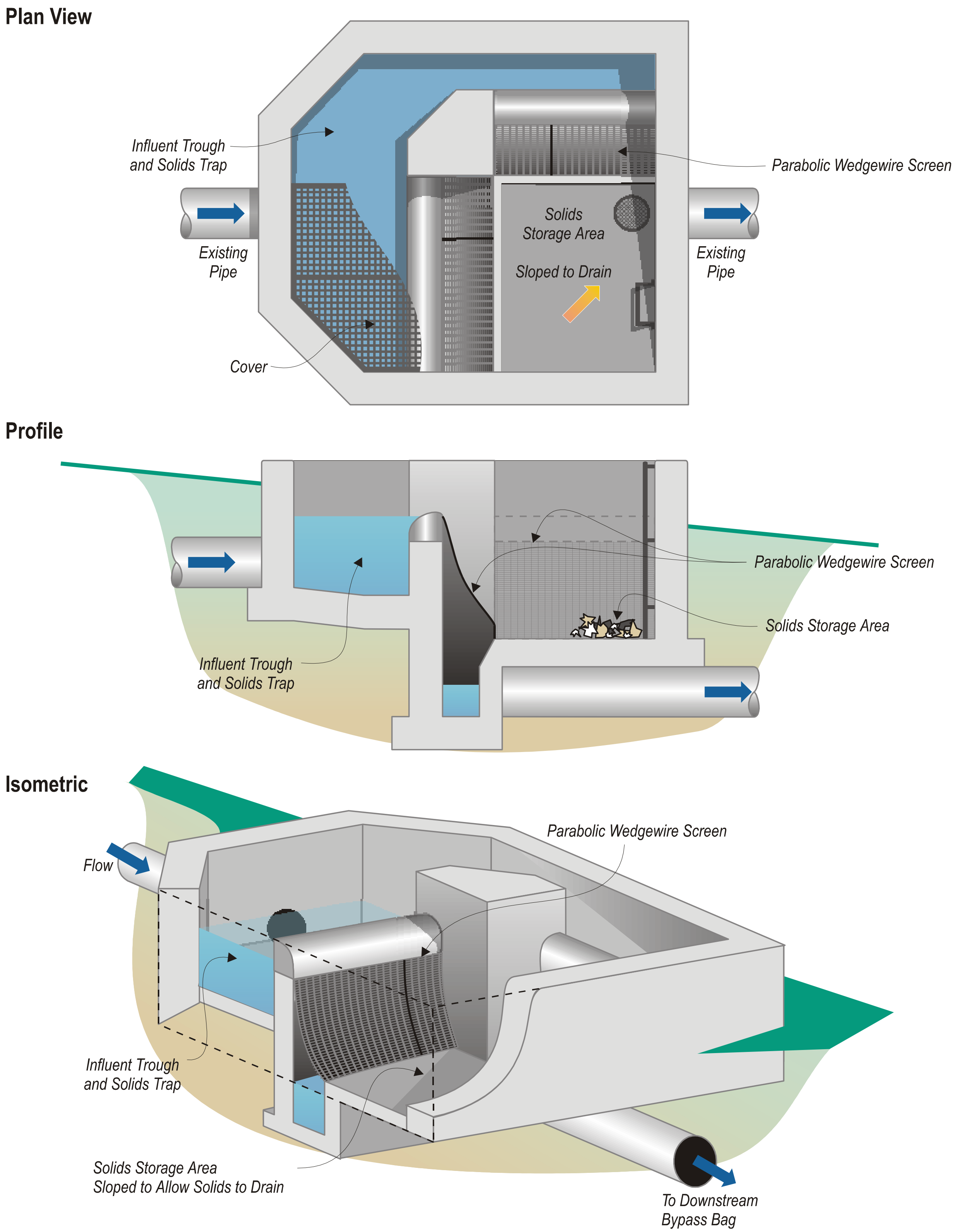


Figure 2-3
Concept Inclined Screen
Configuration #1

2.2.4 Inclined Screen – Configuration #2

This GSRD uses a 5 mm (0.2 in nominal) spaced parabolic bar screen with the slotting parallel (vertical orientation) to the direction of flow (Figure 2-4). The device is configured with an influent trough to allow solids to settle. The flow overtops a weir and falls through the inclined screen located after the influent trough. After passing through the screen, the flow exits the GSRD. Gross solids are retained in a confined storage area that can be accessed by maintenance equipment. Key design and operational concepts are as follows:

- Inflows enter a trough to distribute flows along the length of the screen. The trough also provides an area of reduced velocity where larger solids can settle.
- The trough is drained by a series of small plastic risers. Sufficient risers are provided to drain the trough within 72 hours to prevent vector propagation.
- Flowing storm water pushes the gross solids. The gross solids are moved by gravity down the face of the screen to the gross solids storage area.
- The gross solids storage area is sloped to allow it to drain between storm events.
- The vault can be configured with grates or covers, traffic or non-traffic rated, depending upon location within the highway right-of-way.
- An overflow weir is provided to convey emergency bypass flow, and an overflow basket is attached to capture any solids that flow over the weir.

2.2.5 Baffle Box

This GSRD applies a two-chamber concept: the first chamber utilizes an underflow weir to trap floatable gross solids, and the second chamber uses a bar rack to capture materials that get past the underflow weir (Figure 2-5). Key design and operational concepts are as follows:

- Inflow enters the first chamber, where solids are allowed to settle.
- A hinged chain-link screen allows high flows to pass and keeps the majority of floatable solids in the first chamber.
- The flow of storm water along the slotted screen is designed to provide a self-cleaning action. The slotted screen is sized to accommodate partial plugging.
- Plastic risers in the first chamber drain water from the device, allowing solids to fall to the bottom of the chamber.
- An overflow weir is provided to convey emergency bypass flow, and an overflow basket is attached to capture any solids that flow over the weir.

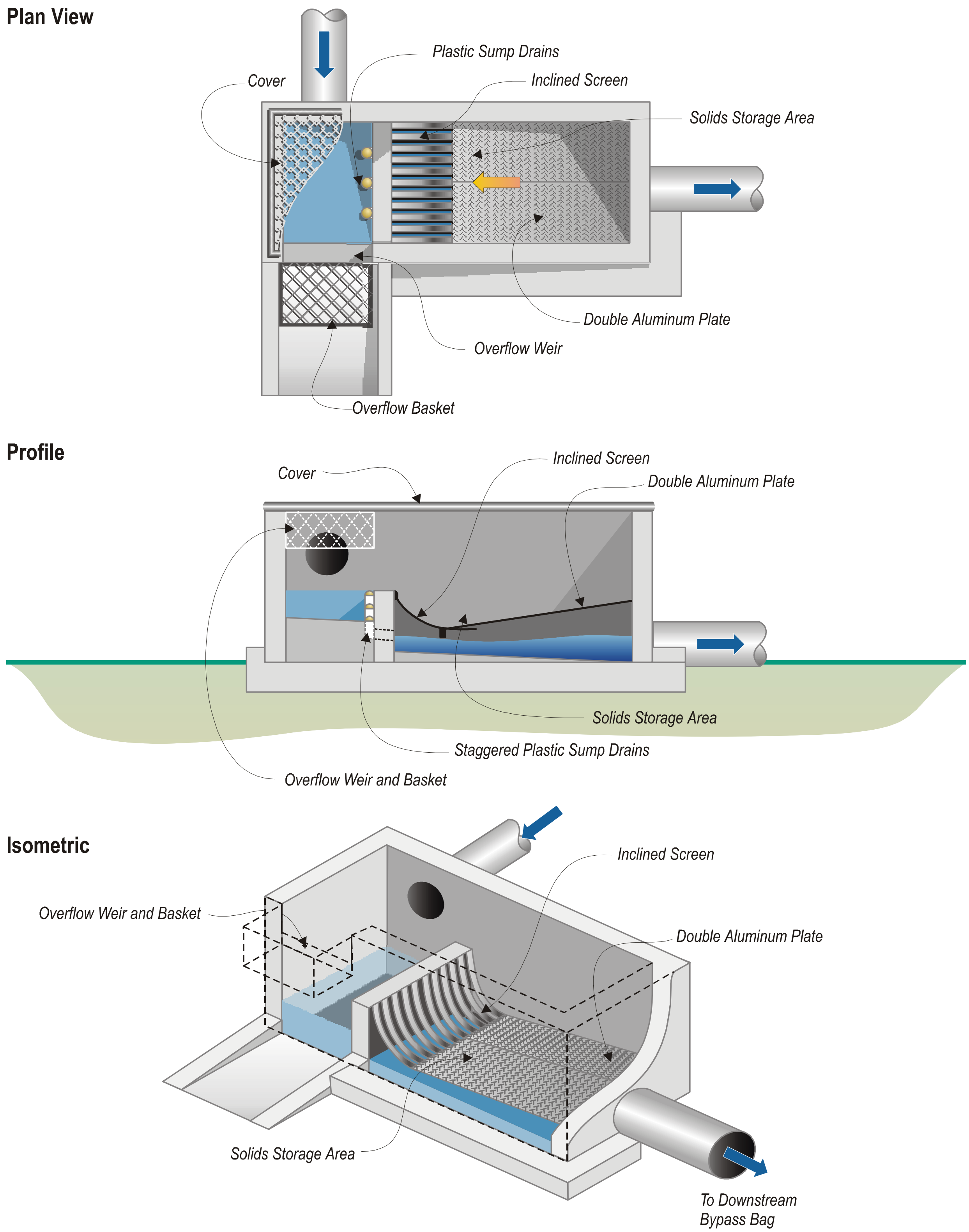


Figure 2-4
Concept Inclined Screen
Configuration #2

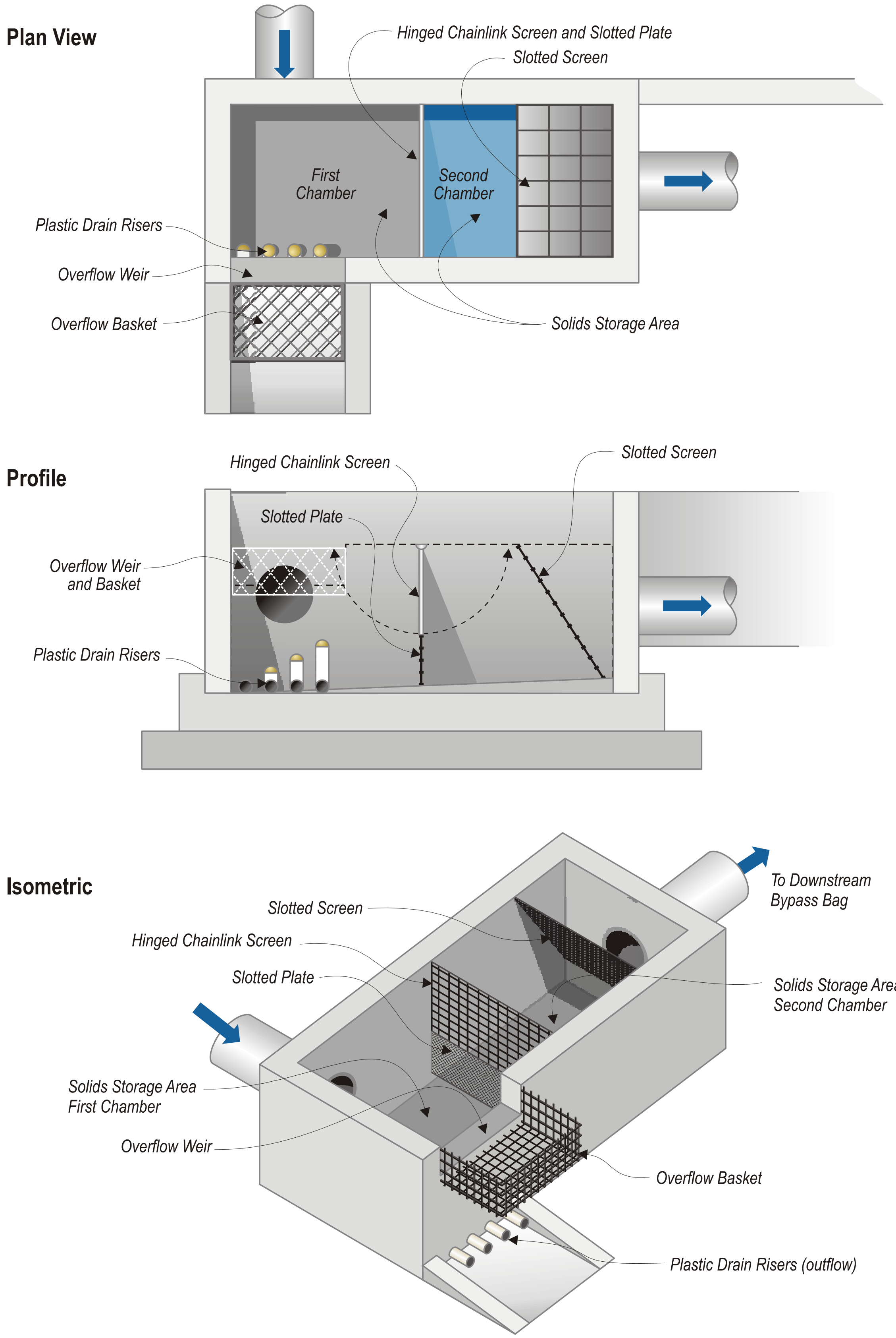


Figure 2-5
Concept Baffle Box

2.3 DESIGN CRITERIA AND FINAL DESIGN

The design concepts, including the variations, were divided into two groups. Group A consisted of the Linear Radial – Configuration #1 and Inclined Screen – Configuration #1. Group B consisted of the Linear Radial – Configuration #2; Inclined Screen – Configuration #2; and the Baffle Box.

The design criteria applied for the Phase I GSRDs Pilot Study included: primary design goals, hydrology, hydraulics, vector control, operation and maintenance objectives, and an estimated annual gross solids loading rate. The estimated annual gross solids loading rate used for this study is 0.7 m^3/ha (10 ft^3/ac). The gross solid loading rate and the other design elements are discussed further in the following two reports: Design elements for the Group A GSRDs are presented in the Caltrans *Preliminary Design Report Litter Solids Removal Device* (Caltrans, 2001b); design elements for the Group B GSRDs are presented in the Caltrans *Basis of Design Report Litter Solids Removal Device Pilot Study* (Caltrans, 2001c).

Section 3
Site Selection and Installation

3.1 SITE SELECTION

The site selection process, including the siting criteria, for the Phase I GSRD Pilot Study is discussed in the Preliminary Design Report (Caltrans, 2001b) and the Basis of Design Report (Caltrans, 2001c). The site selection process identified and ranked over 70 candidate sites. From these candidate sites, eight sites were selected for installation of pilot GSRDs. The site selection process identified the most suitable sites for the pilot study. The sites provided sufficient access and safety for installation and monitoring. The sites not selected for the pilot study will eventually be retrofitted to comply with the TMDL.

3.2 SITE DESCRIPTIONS

The sites selected for the eight GSRDs are all located within Caltrans District 7 and within the Los Angeles River Watershed. Site descriptions are provided in Table 3-1. The table also provides the naming convention that is used throughout the rest of the report to describe each site by GSRD type and freeway location. Figure 3-1 shows the approximate site locations of the GSRDs. Descriptions and photos of each site are presented in the following subsections.

3.2.1 Linear Radial GSRDs

Three Linear Radial GSRDs were installed at various locations within Caltrans District 7, using two configurations. Configuration #1 used a louvered well screen as the screening mechanism; Configuration #2 used a rigid mesh screen.

Table 3-1
GSRD Site Location Summary

Site ID	Site Name	GSRD Type & Configuration	Site Name Used in this Report	City	Route	Direction	Kilometer Post (KP)	Drainage Area ha (ac)	% Roadway Runoff
1	I-10 at Rosemead	Linear Radial – 1	LR1 I-10	Rosemead	10	Westbound	44.1	1.5 (3.7)[1]	100%
2	I-210 at Glenada	Linear Radial – 2	LR2 I-210	La Crescenta	210	Eastbound	30.0	2.5 (6.2)[2]	100%
3	I-5 at Garber	Linear Radial – 2	LR2 I-5	Pacoima	5	Southbound	61.0	0.4 (0.9)[2]	100%
4	SR-170 at KP 26.1	Inclined Screen – 1	IS1 SR-170	North Hollywood	170	Northbound	26.1	1.0 (2.5)[1]	100%
5	I-210 at Orcas	Inclined Screen – 2	IS2 I-210	Lake View Terrace	210	Westbound	13.5	1.4 (3.4)[2]	100%
6	US-101 at Gaviota	Inclined Screen – 2	IS2 US-101	Encino	101	Eastbound	28.7	0.8 (2.1)[2]	100%
7	I-405 at Leadwell	Baffle Box	BB I-405	Van Nuys	405	Southbound	68.5	1.2 (3.0)[2]	100%
8	I-210 at Christy	Baffle Box	BB I-210	Lake View Terrace	210	Eastbound	14.7	0.9 (2.3)[2]	100%

[1] Based on detailed site surveys.

[2] Based on available record drawings (“As-Builts”). Detailed site surveys were not performed.

Note: For reporting purposes, total drainage area for both S.I. units and U.S. Customary has been reported to the nearest tenth

Figure 3-1
Phase I GSRDs Location Map

3.2.1.1 I-10 at Rosemead: Linear Radial – Configuration #1

This Linear Radial GSRD site is located in the City of Rosemead at KP 44.1 (PM 27.4) on the westbound side of Interstate 10. Access to the site for monitoring is through an access gate at the intersection of Rio Hondo Avenue and Ramona Boulevard (the frontage road east of the Rosemead Boulevard off ramp). Access for installation and maintenance is from the westbound I-10 freeway. This site is characterized by:

- Six inlets located along the freeway shoulder
- One outlet, 600 mm (24 in) in diameter
- Drainage area of approximately 1.5 ha (3.7 ac)

Traffic control was not required during installation of the device. Additionally, traffic control was not required for monitoring since the site is accessible from the access gate at the intersection of Rio Hondo Avenue and Ramona Boulevard. There is approximately 7.6 m (25 ft) of open ground and vegetation between the guardrail and the sound wall at this site. Some vegetation removal was required for implementation. Due to site constraints, the overflow open top has a smaller area than the area of the influent pipe, but additional inspection ports also provided overflow capability.

Figure 3-2
LR-1 I-10 After Installation

3.2.1.2 I-210 at Glenada: Linear Radial – Configuration #2

This Linear Radial GSRD site is located in the City of La Crescenta at Glenada Avenue along the eastbound direction of Interstate 210. Access to the site for installation, maintenance, and monitoring purposes is from the end of the Glenada Avenue cul-de-sac. This site is characterized by:

- Twelve inlets located along the freeway shoulder
- One outlet, 900 mm (36 in) in diameter
- Drainage area of approximately 2.5 ha (6.2 ac)

The site was a vegetated area in the Caltrans right-of-way at the end of a residential cul-de-sac. Some vegetation removal was required for the implementation of the device.

Figure 3-3
LR2 I-210 After Installation

3.2.1.3 I-5 at Garber: Linear Radial – Configuration #2

This Linear Radial GSRD site is located in the City of Pacoima at the intersection of Sharp Avenue and Garber Street along the southbound side of Interstate 5. Access to the site for installation, maintenance, and monitoring purposes is from the end of Garber Street where it dead-ends at Sharp Avenue. This site is characterized by:

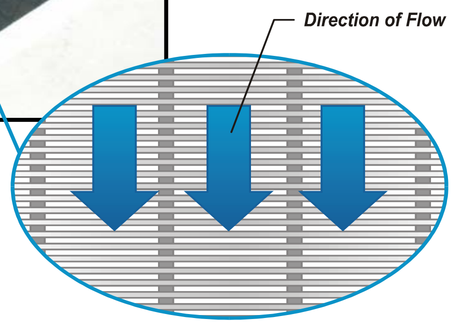
- Three inlets located along the freeway shoulder and 2 inlets along the centerline
- One outlet, 450 mm (18 in) in diameter
- Drainage area of approximately 0.4 ha (0.9 ac)

The site was a grassy area in the Caltrans right-of-way below the existing sound wall. Minimal vegetation removal was required for the implementation of the device.

Figure 3-4
LR2 I-5 After Installation

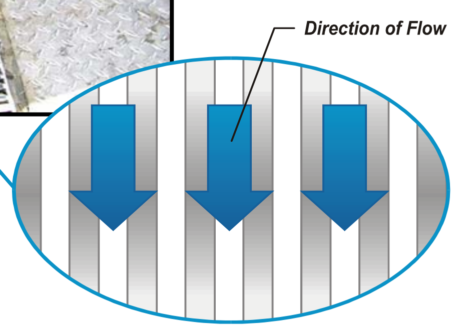
3.2.2 Inclined Screen GSRDs

Three Inclined Screen GSRDs, including two configurations, were implemented at various locations within Caltrans District 7. Configuration #1 used a 3 mm (0.125 in) spaced parabolic wedge wire screen with the slotting perpendicular (horizontal orientation) to the direction of flow (Figure 3-5). Configuration #2 used a 5 mm (0.2 in) bar screen with the slotting parallel (vertical orientation) to the direction of flow (Figure 3-5). The screens in both configurations are parabolic in shape with Configuration #1 set at a much steeper inclination.



Configuration #1

Screen Opening: 3mm *(0.125 in nominal)*



Configuration #2

Screen Opening: 5mm *(0.25 in nominal)*

Figure 3-5
Configurations of Inclined Screens

3.2.2.1 SR-170 at KP 26.1 (PM 16.2): Inclined Screen – Configuration #1

This Inclined Screen GSRD site is located at KP 26.1 (PM 16.2) in the City of North Hollywood along the northbound side of State Route 170. Access to the site for maintenance and monitoring requires parking in the gravel turnout installed along the shoulder of the highway. This site is characterized by:

- Four inlets located along the freeway shoulder and 1 inlet along the freeway centerline
- One outlet, 450 mm (18 in) in diameter
- Drainage area of approximately 1.0 ha (2.5 ac)

The site was heavily vegetated and did not provide adequate vehicle access. During the installation phase, some vegetation was removed so that a vehicular access turnout area could be installed. In addition, existing utilities in the vicinity were protected in place. Irrigation risers were cut below grade and capped along the gravel access turnout. Minimal traffic control along the shoulder was required during installation of the turnout. No traffic control was required for monitoring or maintenance because the access turnout was provided.

Figure 3-6
IS1 SR-170 After Installation

3.2.2.2 I-210 at Orcas: Inclined Screen – Configuration #2

This site is located in the City of Lake View Terrace just off the south side of Foothill Boulevard near Orcas Avenue along the westbound side of Interstate 210. Access to the site for installation, maintenance, and monitoring purposes is from Foothill Boulevard across from the Lakeview Terrace Recreation Center. This site is characterized by:

- Four inlets located along the freeway shoulder
- One outlet, 450 mm (18 in) in diameter
- Drainage area of approximately 1.4 ha (3.4 ac)

The site is immediately adjacent to flood channel running parallel to both Interstate 210 and Foothill Boulevard. The site is in the Caltrans right-of-way below the sound wall on westbound Interstate 210. Minimal vegetation removal was required for the implementation of the device.

Figure 3-7
IS2 I-210 After Installation

3.2.2.3 US-101 at Gaviota: Inclined Screen – Configuration #2

This site is located in the City of Encino just north of Magnolia Boulevard near Gaviota Avenue below the eastbound side of US-101 Freeway. Access to the site for installation, maintenance, and monitoring purposes is from Magnolia Boulevard at the intersection with Gaviota Avenue. This site is characterized by:

- Five inlets located along the freeway shoulder and 10 inlets along the centerline of the freeway
- Two outlets, 300 mm (12 in) and 450 mm (18 in) in diameter
- Drainage area of approximately 0.8 ha (2.1 ac)

The site is a sloped, grassy parcel, with many trees, in the Caltrans right-of-way below the sound wall on eastbound US-101 Freeway. Minimal vegetation removal was required for the implementation of the device.

Figure 3-8
IS2 US-101 After Installation

3.2.3 Baffle Box GSRDs

Two Baffle Box GSRDs were installed within Caltrans District 7. The same configuration was used at both locations.

3.2.3.1 I-405 at Leadwell: Baffle Box

This site is located in the City of Van Nuys at the end of a cul-de-sac on Leadwell Street below the southbound side of Interstate 405. Access to the site for installation, maintenance, and monitoring purposes is from Leadwell Street. This site is characterized by:

- Two inlets located along the freeway shoulder and 1 inlet along the freeway centerline
- One outlet, 450 mm (18 in) in diameter
- Drainage area of approximately 1.2 ha (3.0 ac)

The site is a grassy parcel in the Caltrans right-of-way below the sound wall along southbound Interstate 405. Minimal vegetation removal was required for the implementation of the device.

Figure 3-9
BB I-405 After Installation

3.2.3.2 I-210 at Christy: Baffle Box

This site is located in the City of Lake View Terrace just off Christy Avenue below the eastbound side of Interstate 210. Access to the site for installation, maintenance, and monitoring purposes is from Christy Avenue via Foothill Boulevard. This site is characterized by:

- Three inlets located along the freeway shoulder
- One outlet, 450 mm (18 in) in diameter
- Drainage area of approximately 0.9 ha (2.3 ac)

The site is a sloped, grassy parcel in the Caltrans right-of-way below the sound wall on eastbound Interstate 210. Minimal vegetation removal was required for the implementation of the device.

Figure 3-10
BB I-210 After Installation

3.3 INSTALLATION SUMMARY

3.3.1 Installation Schedules

Installation schedules for the GSRDs are presented in Table 3-2. Installation included supporting structure, screens, and miscellaneous appurtenances. The installation periods ranged from 21 days at the LR2 I-210 site to 37 working days at the BB I-210 site.

Table 3-2
GSRD Installation Schedules

Site	Start Date	Finish Date	Working Days
LR1 I-10	11/12/00	12/17/00	25
LR2 I-210	01/05/01	02/02/01	21
LR2 I-5	11/13/00	12/29/00	35
IS1 SR-170	11/25/00	12/30/00	25
IS2 I-210	11/09/00	12/29/00	34
IS2 US-101	11/15/00	01/10/01	36
BB I-405	11/15/00	12/29/00	33
BB I-210	11/13/00	01/09/01	37

3.3.2 Installation Costs

Installation costs for the GSRDs are presented in Table 3-3. The costs of the GSRDs varied from site to site as well as between GSRD types. Installation costs ranged from $32,200/ha ($13,000/ac) at the LR1 I-10 site to $235,970/ha ($95,500/ac) at the LR2 I-5 site, not including monitoring equipment costs. Variability in cost is due to site-specific requirements.

Table 3-3
GSRD Installation Costs

Site	Drainage Area ha (ac)	Total Cost[1]	Without Monitoring Equipment		
			Cost	Cost per hectare	Cost per acre
LR1 I-10	1.5 (3.7)	$66,200	$48,300	$32,200	$13,054
LR2 I-210	2.5 (6.2)	$172,009	$155,935	$62,374	$25,151
LR2 I-5	0.4 (0.9)	$110,462	$94,388	$235,970	$104,876
IS1 SR-170	1.0 (2.5)	$100,800	$82,800	$82,800	$33,120
IS2 I-210	1.4 (3.4)	$150,425	$134,351	$95,965	$39,515
IS2 US-101	0.8 (2.1)	$151,337	$135,263	$169,078	$64,411
BB I-405	1.2 (3.0)	$129,422	$113,348	$94,457	$37,783
BB I-210	0.9 (2.3)	$135,629	$119,555	$132,839	$51,980

[1]Total cost includes the cost of monitoring equipment. ENR Construction Cost Index = 6283 (Dec. 2000) and 6281 (Jan. 2001).

3.3.3 Installation Issues

The installation of the GSRDs proceeded as planned, except for a few unforeseen circumstances. These circumstances are described below, grouped by common issues.

3.3.3.1 Material Availability

There were lengthy shop drawing and manufacturing lead times associated with the custom fabricated inclined screens (Sites IS2 I-210 and IS2 US-101) and the galvanized stainless steel basket screens (Sites LR2 I-210 and LR2 I-5). There were also long lead times related to the mesh bags because they had to be fabricated with UV resistant materials able to withstand accumulated sediment, tree branches, mud, etc.

3.3.3.2 Field Conditions

Unidentified underground utilities, extensive site excavation, grading requirements, and site vegetation led to additional field installation time and effort, and therefore increased cost, at some sites. Over-excavation, backfill, and compaction were required at some of the sites. Although Underground Service Alert was notified of the installation, unidentified utilities were exposed at a number of the sites. The utilities were wrapped in plastic and left in place.

Riprap rocks in the flood control channel at the IS2 I-210 site had to be individually moved and then placed back in their appropriate position to allow the access driveway to be installed. Large trees at the LR2 I-210 and BB I-405 sites had to be trimmed back to minimize the amount of vegetation falling into the GSRD. The IS1 SR-170 site required the removal of minor vegetation that was interfering with installation.

3.3.3.3 Public Impact

The GSRDs in general caused minimal impact to the local neighborhoods during and after installation. However, the resident of a home adjacent to the BB I-210 site sent a letter to Caltrans complaining of the unsightliness of the GSRD. Additional landscaping, including shrubs and bushes, were added to mitigate the visual impact of the GSRD. Installation of the LR2 I-210 site required the addition of K-rail for traffic control; however, traffic was only disrupted during the period that the K-rail was being installed.

The new fence at the LR2 I-5 site disrupted pedestrian traffic along a dirt path, mainly used by children walking to school. This resulted in several occurrences of the fence being damaged to allow the children access to the dirt path. The fence was relocated to allow the children to use the path. During the installation period, field vehicles at the LR2 I-5, LR2 I-210, IS2 US-101, BB I-210, and BB I-405 sites interfered with neighborhood street parking. Although this impact was temporary, the installation crews always attempted to minimize the number of vehicles at each site. No disruption to the public was caused at the LR1 I-10 and IS1 SR-170 sites.

Section 4
Monitoring and Operational Observations

4.1 OVERVIEW

This section summarizes the monitoring procedures applied to the Phase I GSRDs Pilot Study and the operational observations at each GSRD during the two storm seasons.

4.2 MONITORING PROCEDURES

4.2.1 Water Quality Monitoring

Water quality monitoring was conducted for the 2000-01 storm season according to the procedures presented in the Sampling and Analysis Plan (Caltrans, 2001a). The water quality monitoring component was removed from the study for the second storm season, 2001-02, because the TMDL focuses on litter only. The water quality data is not presented in this report since less than one year of data was collected. However, the Interim Report (Caltrans, 2001e) presents the limited water quality data collected from the first storm season. No conclusions could be drawn regarding water quality performance from the limited data gathered.

4.2.2 Gross Solids Monitoring

Monitoring procedures for the 2000-01 and 2001-02 storm seasons are presented in the Sampling and Analysis Plan (Caltrans, 2001a). In summary, the following tasks were conducted following a targeted storm event:

- Took digital photos of the device;
- Assessed device for clogging;
- Estimated the amount of gross solids accumulation within the device to assess if an interim cleaning would be required;
- Observed the accumulation and distribution of gross solids within the device;
- Checked the bypass bag and overflow basket for material accumulation; and
- Verified that the device was draining properly.

Each GSRD was designed to be cleaned only once per storm season. However, if a device was determined, by visual observation, to have reached approximately 85 percent of capacity, or if extensive clogging or overflow was observed at a device, an additional cleaning was performed during the season. As a result, some GSRDs were cleaned more than once. During each cleaning procedure, four measurements were taken:

- Wet weight of the gross solids removed from the device;
- Wet volume of the gross solids removed from the device;

- Wet weight of the gross solids removed from the bypass bag and overflow basket (if applicable); and
- Wet volume of the gross solids removed from the bypass bag and overflow basket (if applicable).

Weight and volume measurements were taken only during a cleaning. If multiple cleanings were required at a site, the data from each interim cleaning and the end-of-season cleaning were added together to obtain an annual gross solids loading for that site. Measurements were not taken on a per storm event basis.

4.2.2.1 Field Measurements

The weight of gross solids was estimated by first placing the empty container on an electronic scale and taking the tare weight of the scale, minimizing the compaction of gross solids. The bags of gross solids (one at a time) were placed in the container, and weighed on the scale. Field weight measurements from all bags for a single GSRD device were added together and the total weight calculated for that device.

The volume of gross solids was estimated by placing the bags of gross solids (one at a time) into a container of known volume. The bag was made as level as possible across the entire surface area of the container. The amount of freeboard was then measured and multiplied by the surface area of the container to obtain the remaining volume. This quantity was then subtracted from the total known volume of the container to yield the estimated volume of gross solids. Field volume measurements from all bags for a single GSRD device were added together and the total volume calculated for that device.

4.2.2.2 Laboratory Analysis

During the 2000-01 storm season, the gross solids were shipped to the Caltrans Litter Laboratory using the procedures outlined in the Sampling and Analysis Plan (Caltrans, 2001a). At the Caltrans Litter Laboratory, the gross solids were separated into litter and vegetative material, and up to eight additional measurements were taken for the gross solids:

- Initial lab weight of the litter from the device;
- Initial lab volume of the litter from the device;
- Initial lab weight of the vegetation from the device;
- Initial lab volume of the vegetation from the device;
- Initial lab weight of the litter from the bypass bag and overflow basket (if applicable);
- Initial lab volume of the litter from the bypass bag and overflow basket (if applicable);
- Initial lab weight of the vegetation from the bypass bag and overflow basket (if applicable); and

- Initial lab volume of the vegetation from the bypass bag and overflow basket (if applicable).

The litter was then air-dried in the laboratory and up to four additional measurements were taken:

- 24-hour air-dried weight of the litter from the device;
- 24-hour air-dried volume of the litter from the device;
- 24-hour air-dried weight of the litter from the bypass bag and overflow basket (if applicable); and
- 24-hour air-dried volume of the litter from the bypass bag and overflow basket (if applicable).

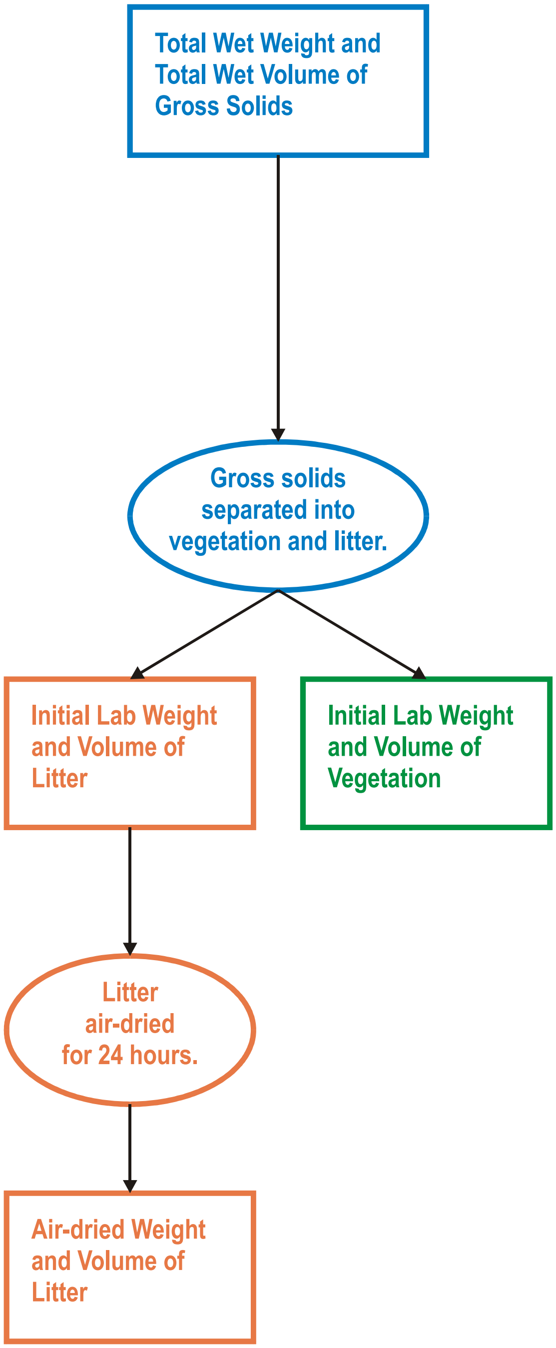
Figure 4-1 shows a flow chart that summarizes the different measurements taken during the first storm season. The Interim Report (Caltrans, 2001e) summarizes all of the data collected from the first storm season. The 24-hour air-dried and initial lab measurements are also provided in Appendix A of this report.

For the 2001-02 storm season, there were no air-dried analyses performed because they were not deemed critical for TMDL compliance. During the 2001-02 storm season, the tasks performed following a targeted storm event remained the same. The measurements taken after each cleaning also remained the same. Section 5 summarizes the data of wet weight and wet volume measurements for both seasons.

4.2.3 Mobilization Criteria

The mobilization criteria varied between the two storm seasons. During the 2000-01 storm season, storm events with a predicted rainfall of at least 2.5 mm (0.10 in), and a 75 percent or greater probability, triggered the deployment of field teams. For storm events with a predicted rainfall of 2.5 mm (0.10 in) or greater, and a 50 percent to 75 percent probability, the decision to deploy field teams was determined on a storm-by-storm basis. The mobilization threshold for the first season was tied to the water quality monitoring component.

The water quality monitoring component was removed from the study for the second storm season, 2001-02, and the mobilization threshold changed as a result. Post-storm field inspections were conducted after a rain event which produced at least 12.7 mm (0.50 in) of rain. During-storm field inspections were conducted when at least 12.7 mm (0.50 in) of rain was forecast with a minimum of 50 percent probability, and it had started raining.



First Measurement (Total Wet Weight and Volume)

Total wet weight and volume of gross solids taken in the field. At each GSRD, the measurements for the gross solids captured in a GSRD were recorded separately from the measurements for the gross solids collected in the bypass bag and/or overflow structure. The gross solids were transferred to a plastic bag for weight and volume measurements. During the second season of monitoring, these were the only measurements taken.

Second Measurement (Initial Lab Weight and Volume)

Once the gross solids arrived at the lab, the gross solids were separated into vegetative material and litter. Again, for each GSRD, the measurements for the gross solids captured in a GSRD were recorded separately from the measurements for the gross solids collected in the bypass bag and/or overflow structure. Each component, i.e., vegetative material and litter, was measured for weight and volume. In Appendix A, these values are referred to as the Initial Lab Weight and Volume. In the Phase I Interim Report (Caltrans, 2001e), these values are referred to as Litter Wet Weight and Wet Volume and Vegetation Wet Weight and Wet Volume.

Third Measurement (Air-dried Weight and Volume)

After the gross solids are separated into vegetative material and litter, and after the Initial Lab Weights and Volumes are taken of the components, the litter is air-dried for 24 hours. Again, the measurements for the gross solids captured in a GSRD were recorded separately from the measurements for the gross solids collected in the bypass bag and/or overflow structure. After the 24 hours, the weight and volume measurements for the litter are taken. In Appendix A, these values are referred to as the Air-dried Weight and Volume.

Figure 4-1
Flow Chart of Gross Solids Measurements
for 2000-2001 Storm Season

4.3 GSRD OPERATION AND CLEANINGS

Descriptions of the operation and cleaning of each GSRD during the 2000-01 and 2001-02 storm seasons are presented in the following sections. The average time required and equipment used for the interim and post-season cleanings are summarized in Table 4-1. This data represents the efforts needed to clean the GSRDs, collect the captured and bypassed gross solids, take field measurements of the weight and volume of gross solids (wet weight and wet volume), and dispose of the gross solids outside of the Caltrans right-of-way. For pilot project operations, gross solids are shoveled into bags for field measurements. Many times during cleaning, the gross solids are still partially wet, therefore taking longer to shovel and move the heavier material. The devices are also swept clean to account for any remaining gross solids. The screens are cleaned with a wire brush to remove and collect any accumulated material on the screens. Gross solids are also scraped and collected from the bypass bag and overflow basket, where applicable. The bypass bags are checked for visible signs of any holes or rips. It is important to note that even though the devices are designed to have a maintenance interval of one year, some of the GSRDs were cleaned more than once due to observed clogging, overflow, or the device was observed to be 85 percent full.

Table 4-1
Phase I GSRDs Pilot Study Cleaning Requirements

Site	Total Number of Cleanings		Average Person-hours per Storm Season	Average Person-hours per Cleaning	Equipment
	2000-01	2001-02			
LR1 I-10	1	1	24	24	A
LR2 I-210	1	2 X,Y	36	24	B
LR2 I-5	2 X	2 Y	16	8	C
IS1 SR-170	1	1	12	12	C
IS2 I-210	2 Y	1	12	8	C
IS2 US-101	2 Y	2 Y	24	12	C
BB I-405	2 Y	2 Y	24	12	C
BB I-210	2 Y	1	18	12	C

A. Shovels, Rakes, Brooms, Brushes, Boom Truck
B. Shovels, Rakes, Brooms, Brushes, Wheelbarrows, Dump Truck/Flatbed Truck
C. Shovels, Rakes, Brooms, Brushes, Pick-Up Truck
X. Device observed to be 85% full or more.
Y. Device cleaned due to observed clogging and overflow.

The cleaning efforts required for the pilot project are much greater than the level of effort expected for normal cleaning of the devices due to the monitoring aspect of the pilot study. In the event that the devices are approved by Caltrans for permanent use, and transferred to the District for operations and maintenance, the expected cleaning method for each GSRD is listed in Table 4-2. Most GSRDs are designed to be cleaned with a Vactor truck. The expected cleaning for the LR2 configuration requires the manual removal of mesh bags and shoveling of gross solids collected in the concrete vault.

The LR1 I-10 can either be cleaned on-site with a Vactor truck, or a boom truck can be used to transport the GSRD off-site for complete device disassembly. Boom trucks would pick up LR1 type GSRDs at multiple sites. After the devices are cleaned off-site, the boom truck would return to other LR1 sites and swap the dirty devices with clean devices.

Table 4-2
Phase I GSRDs Expected Cleaning Method

Site	Expected Cleaning Method
LR1 I-10	Vactor Truck or Boom Truck
LR2 I-210	Manual Bag Removal
LR2 I-5	Manual Bag Removal
IS1 SR-170	Vactor Truck
IS2 I-210	Vactor Truck
IS2 US-101	Vactor Truck
BB I-405	Vactor Truck
BB I-210	Vactor Truck

4.3.1 Data Collection Points for GSRDs

The GSRDs captured gross solids in different areas of the device. The collection points for the GSRDs are listed in Table 4-2.

Table 4-3
Phase I GSRDs Data Collection Points

Site	Within Device	Bypass/Overflow
LR1 I-10	Inside louvered screen and concrete vault	Overflow/bypass bag
LR2 I-210	Inside mesh bag, rigid mesh screen, and concrete vault	Overflow/bypass bag
LR2 I-5	Inside mesh bag, rigid mesh screen, and concrete vault	Overflow/bypass bag
IS1 SR-170	Influent trough and solids storage area	Bypass bag
IS2 I-210	Influent trough and solids storage area	Overflow basket and bypass bag
IS2 US-101	Influent trough and solids storage area	Overflow basket and bypass bag
BB I-405	First and second chambers	Overflow basket and bypass bag
BB I-210	First and second chambers	Overflow basket and bypass bag

4.3.2 I-10 at Rosemead: Linear Radial – Configuration #1

This device became operational December 18, 2000. Eight storms were monitored during the 2000-01 storm season at the GSRD located at LR1 I-10. The first storm event on January 10, 2001 totaled 88 mm (3.5 in) of rain over an 18-hour period. This large event was equivalent to a 10 to 25-year, 24-hour event based upon historic rainfall data. The greatest solids accumulation observed for any single storm over the two-year monitoring period accompanied this large storm event. Accumulation of gross solids was relatively small for the remainder of the season. The device conveyed the storm flows during this event and all subsequent events without going into an overflow/bypass mode. The small amount of gross solids captured by the overflow/bypass bag was attributed to material being blown into the device. The gross solids collected in the overflow/bypass bag consisted of larger sized material including large leaves and plastic bags. Since there was no evidence of overflow, the conclusion is that the solids in the bag must have been wind blown. The GSRD was cleaned once at the end of the season.

During the 2001-02 storm season, the LR1 I-10 was inspected eight times and cleaned once at the end of the season. Inspection reports indicated that the device gradually filled up with gross solids throughout the season. After the first storm, the device was observed to be approximately 30 percent full. Towards the end of the season, the downstream end of the device was approximately 60 percent full while the upstream end was approximately 20 percent full. Based on these observations, the GSRD operated successfully and was capable of capturing the annual gross solids volume. As opposed to the first storm season, no material accumulated in the overflow/bypass bag during the 2001-02 season, possibly due to variability in wind conditions and/or other unknown factors. The device was cleaned once at the end of the season.

End-of-season cleaning of this GSRD during the monitoring project involved disassembly of the GSRD, using a truck boom to load the screen onto a truck, and transport the screen to an off-site facility to be emptied and cleaned. This cleaning procedure was used to make sure that all the gross solids were properly collected and measured for weight and volume.

Figure 4-2
LR1 I-10 During Monitoring

4.3.3 I-210 at Glenada: Linear Radial – Configuration #2

This device became operational February 5, 2001. Five storms were monitored during the 2000-01 storm season at LR2 I-210. The site was not operational during storm events in January, including the large storm event of January 10, 2001. During the remainder of the storm season, the device captured large quantities of vegetation and sediment (sand and soil). This material accumulated at the front of the device, inhibiting flow and backing up storm water in the drainage channel. The GSRD was cleaned once at the end of the season.

During the 2001-02 storm season, the LR2 I-210 was inspected eight times, cleaned once during the season and once at the end of the season. The GSRD filled up with gross solids faster than expected and required cleaning during the season on January 16, 2002. The cleaning was conducted based on observation that capacity of the device exceeded 85 percent full. Clogging and overflowing in the upstream end due to an abundance of sediment and vegetation were often observed during inspections. A fraction of gross solids captured by the overflow/bypass bag can be attributed to material being blown into the inflow channel to the device. Based on field observations over the two storm seasons, this amount of wind-blown material can be considered insignificant.

Cleaning of the device involved a three-person crew removing the nylon mesh bags from the screen housing and transferring the gross solids from the mesh bags into trash bags to be measured for weight and volume. Wheelbarrows were used to transport the material to a dump truck. Gross solids from the inflow and outflow channels were also shoveled into trash bags to be measured for weight and volume. A large quantity of material accumulated in the inflow channel before the screens.

Figure 4-3
LR2 I-210 During Monitoring

4.3.4 I-5 at Garber: Linear Radial – Configuration #2

This device became operational January 2, 2001. Seven storms were monitored during the 2000-01 storm season at the LR2 I-5. This GSRD captured a large amount of litter, vegetation and natural sediment during the January 10, 2001 storm. The quantity was such that the GSRD had to be cleaned immediately thereafter to prevent blockage of flow during the remainder of the season. The cleaning was conducted based on observation that capacity of the device exceeded 85 percent full. Accumulation during the February, March, and April storms was small relative to the large January storm. A fraction of gross solids captured by the overflow/bypass bag can be attributed to material being blown into the open area downstream of the device. However, based on field observations, this amount of wind-blown material can be considered insignificant. The GSRD was cleaned again at the end of the season.

During the 2001-02 storm season, the LR2 I-5 was inspected seven times, cleaned once during the season and once at the end of the season. Clogging and evidence of overflowing prompted the mid-season cleaning. Standing water in front of the Fiberglass Reinforced Plastic (FRP) flume was noted on several inspections.

Cleaning of the device involved a two-person crew removing the nylon mesh bags from the screen housing and transferring the gross solids from the mesh bags into trash bags to be measured for weight and volume. Gross solids from the inflow channel and outflow flume were also shoveled into trash bags to be measured for weight and volume.

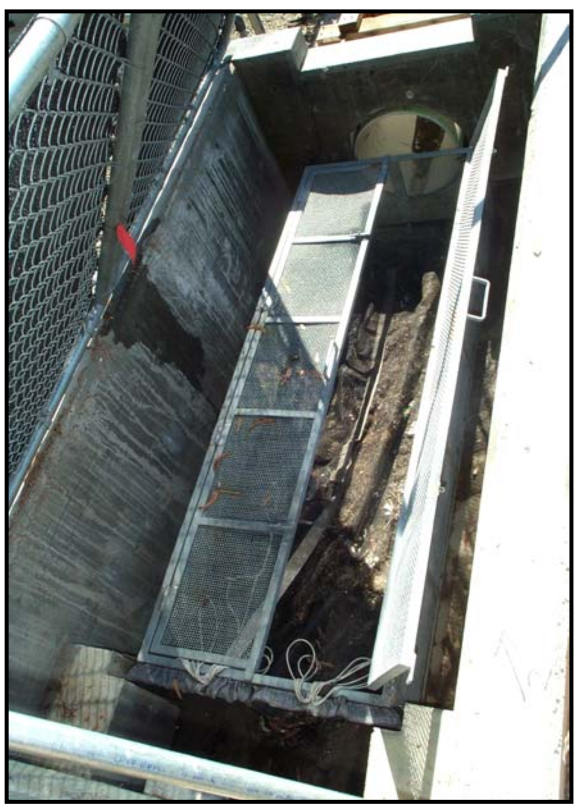


Figure 4-4
LR2 I-5 During Monitoring

4.3.5 SR-170 at KP 26.1: Inclined Screen – Configuration #1

This device became operational January 2, 2001. Eight storms were monitored during the 2000-01 storm season at IS1 SR-170. The first storm event on January 10, 2001 totaled 140 mm (5.5 in) of rain over an 18-hour period. This large event was equivalent to a 10 to 25-year event based upon historic rainfall data. The greatest accumulation of gross solids for any single storm event accompanied this large storm. Accumulation of gross solids was relatively small for the remainder of the season. The GSRD conveyed the storm flows during this event without going into an overflow/bypass mode. The GSRD did require mid-season servicing of the weep holes and installation of additional screening above the weep holes to improve draining of the upper trough. The GSRD was cleaned once at the end of the season.

During the 2001-02 storm season, the IS1 SR-170 was inspected seven times and cleaned once at the end of the season. No operational problems were observed during the inspections.

Cleaning of the device involved a two-person crew shoveling the gross solids from the influent trough and solids storage area into trash bags to be measured for weight and volume. Material that had accumulated beneath the parabolic screens were also collected and measured. The gross solids in the bypass bag were measured separately.

Figure 4-5
IS1 SR-170 During Monitoring

4.3.6 I-210 at Orcas: Inclined Screen – Configuration #2

This device became operational January 2, 2001. Seven storms were monitored during the 2000-01 storm season at the IS2 I-210. The GSRD captured a large amount of litter, vegetation, and natural sediment during the January 10, 2001 storm. The quantity captured was such that the GSRD was observed to plug and overflow, and the device had to be cleaned to prevent blockage of flow during the remainder of the season. Accumulation of gross solids during the February, March, and April storms was small relative to the large January storm. The GSRD was cleaned again at the end of the season.

During the 2001-02 storm season, the IS2 I-210 was inspected seven times and cleaned once at the end of the season. No operational problems were reported from the inspections.

Cleaning of the device involved a two-person crew shoveling the gross solids from the influent trough and solids storage area into trash bags to be measured for weight and volume. Material that had accumulated beneath the parabolic screens and double aluminum plate were also collected and measured. Any material inside the overflow basket and bypass bag was also cleaned and identified as bypass solids.

Figure 4-6
IS2 I-210 During Monitoring

4.3.7 US-101 at Gaviota: Inclined Screen – Configuration #2

This device became operational January 15, 2001. Six storms were monitored during the 2000-01 storm season at the IS2 US-101. This GSRD was also cleaned once after a storm on January 26, 2001, due to clogging and evidence of overflowing. Accumulation during the February, March, and April storms was small relative to the large January storm. The GSRD was also cleaned at the end of the season.

During the 2001-02 storm season, the IS2 US-101 GSRD was inspected eight times, cleaned once during the season on February 13, 2002, and cleaned again at the end of the season. The quantity of material captured was such that the GSRD had to be cleaned to prevent blockage of flow during the remainder of the season. The GSRD also had several operational problems. Standing water, plugging, blinding of the screens, and overflow were observed throughout the season.

Cleaning of the device involved a two-person crew shoveling the gross solids from the influent trough and solids storage area into trash bags to be measured for weight and volume. Material that had accumulated beneath the parabolic screens and double aluminum plate were also collected and measured. Any material inside the overflow basket and bypass bag was also cleaned and identified as bypass solids.

Figure 4-7
IS2 US-101 During Monitoring

4.3.8 I-405 at Leadwell: Baffle Box

This device became operational January 2, 2001. Seven storms were monitored during the 2000-01 storm season at the BB I-405. The GSRD was inundated with vegetation and other debris during the large January 10, 2001 storm. There was a large amount of overflow from the first chamber during this storm. The overflow basket also clogged from the large amount of gross solids, causing it to overflow. The quantity of material captured was such that the GSRD had to be cleaned to prevent blockage of flow during the remainder of the season. Accumulation during the February, March, and April storms was small relative to the large January storm. After each storm, the accumulated debris had to be manually removed from both screens to clear the screen openings. The GSRD was also cleaned at the end of the season.

During the 2001-02 storm season, the BB I-405 was inspected eight times, cleaned once during the season on February 13, 2002, and cleaned again at the end of the season. Problems observed included standing water, blinding of the basket, overflowing, and difficulty draining. In particular, an inspection during a storm revealed that the drain risers had plugged in the first chamber causing storm water to overflow the device.

Cleaning of the device involved a two-person crew shoveling the gross solids from the first and second chambers into trash bags to be measured for weight and volume. Both screens were also scraped and cleaned with wire brushes, and the material that had accumulated on the screens was collected and measured. Any material inside the overflow basket and bypass bag was cleaned and identified as bypass solids.

Figure 4-8
BB I-405 During Monitoring

4.3.9 I-210 at Christy: Baffle Box

This device became operational January 15, 2001. Seven storms were monitored during the 2000-01 storm season at the BB I-210. The GSRD received relatively low amounts of gross solids throughout the season. The GSRD was cleaned after the large January 10, 2001 storm, due to evidence of clogging and overflowing, even though low amounts of gross solids were observed. Accumulation of gross solids was small during the remainder of the season. After each storm, the accumulated debris had to be manually removed from both screens to clear the screen openings.

During the 2001-02 storm season, the BB I-210 GSRD was inspected seven times and cleaned once at the end of the season. Problems noted during the visual inspections include overflowing, blinding of the overflow basket, and standing water.

Cleaning of the device involved a two-person crew shoveling the gross solids from the first and second chambers into trash bags to be measured for weight and volume. Both screens were also scraped and cleaned with wire brushes, and the material that had accumulated on the screens was collected and measured. Any material inside the overflow basket and bypass bag was cleaned and identified as bypass solids.

Figure 4-9
BB I-210 During Monitoring

4.3.10 Linear Radial Additional Observations

The nylon mesh bags utilized in the LR2 configuration had a tendency to collapse, thereby reducing the solids storage capability of the bags. Gross solids deposited in the upstream end of the bags instead of distributing evenly throughout the bag. This problem was particularly apparent for LR2 I-210, which collected a large amount of gross solids in the overflow/bypass bag for both storm seasons. When the upstream end of the bags filled, any additional inflow overtopped the screens and flowed into the overflow/bypass bag. The covers for the rigid mesh screen were not constructed with handles, making it awkward to open and close. In addition, the covers did not offer supports to keep them open.

4.3.11 Inclined Screen Additional Observations

The wedge wire screen for the IS1 SR-170 was installed with 3 mm (0.125 in) openings perpendicular to flow (Figure 3-5). The bar screen for the IS2 I-210 and IS2 US-101 were installed with 5 mm (0.2 in) nominal openings and openings parallel to flow (Figure 3-5). During storms a large amount of gross solids larger than 5 mm (0.2 in) was forced through the bar screen openings by the storm water flow. This resulted in a large quantity of debris captured in the bypass mesh bag.

The screen for the IS1 SR-170 was also steeper than that of the IS2 I-210 and IS2 US-101 (see also Figure 3-5). The steeper inclination facilitated a self-cleaning action when storm water flowed over the screens. As a result, the screen did not blind or plug. The flatter screens experienced partial plugging of the screen due to solids adhering to the face of the screen.

The other major difference between the two configurations was the solids storage area. The solids storage area for IS1 SR-170 had a flat floor and was lowered slightly below the bottom of the parabolic screen, as opposed to IS2 I-210 and IS2 US-101, which had a solids storage floor that sloped towards the screen and ended at the bottom of the screen. As the solids level rose in IS2 I-210 and IS2 US-101, more of the screen became plugged and the device was more apt to overflow.

4.3.12 Baffle Box Additional Observations

The Baffle Boxes were based on a proven design that had been implemented on the south eastern United States. The original design was larger in size and treated a larger drainage area. The original Baffle Boxes contained a permanent pool of water. Due to vector breeding, a change in design was made to prevent standing water in the device.

During the storm season, litter, vegetation, and other debris consistently plugged the screens of the Baffle Box, causing storm water to back up and overflow the first chamber in the Baffle Box. The first chamber screens consisted of a slotted plate at the bottom, which plugged easily, and a swinging chain-link screen at the top to remove larger solids and floatable material. The chain-link screen also had a tendency to plug, and as storm water flow swung the screen forward, the tight tension in the screen kept it in the same forward position throughout the storm. This forward position allowed gross solids to flow past the chain-link screen, which subsequently blinded the second slotted screen in the downstream chamber. However, storm water that made it through all screens and out the effluent pipe was substantially free from gross solids. Very little gross solids were captured in the device's bypass bag.

4.3.13 Gross Solids Disposal

Gross solids were not tested before disposal, since most of the collected material consisted of vegetation, sediment, and litter such as cardboard and plastic. The gross solids were disposed of at dumpsters located at the yards of the companies performing the cleaning and monitoring. No special handling techniques (e.g., hazardous suits or breathing apparatuses) were required during the cleaning operations.

4.4 VECTOR MONITORING

For the Phase I Pilot Study, the Greater Los Angeles County Vector Control District (GLACVCD), and the San Gabriel Valley Mosquito and Vector Control District (SGVMVCD), were contracted to provide vector surveillance and control services at each GSRD from January 2001 through July 2001. Each site was monitored on a weekly basis. The numbers of potential and actual mosquito sources, as well as the number of dips taken at each individual source were recorded. Larval samples were identified to species. The size of the areas treated and amounts of control agents applied were also recorded. Table 4-4 summarizes the vector monitoring for the Phase I Pilot Study.

Table 4-4
Summary of Vector Monitoring

Site	Local Vector Control Agency	Surveillance	Abatement
LR1 I-10	SGVMVCD	No breeding activity detected. The GSRD drained within 72-hours.	No abatement required.
LR2 I-210	GLACVCD	No breeding activity detected. However, the long nylon-mesh bags contained within the rigid mesh screen housing (see Figure 2-2) made it difficult to assess if small amounts of water inside paper cups was present. Inspection reports note that the GSRD, on a few occasions, did not drain within the 72-hour target.	No abatement required.
LR2 I-5	GLACVCD	No breeding activity detected. However, the long nylon-mesh bags contained within the rigid mesh screen housing (see Figure 2-2) made it difficult to assess if small amounts of water inside paper cups was present. Inspection reports note that the GSRD, on a few occasions, did not drain within the 72-hour target.	No abatement required.
IS1 SR-170	GLACVCD	No breeding activity detected. Per recommendations from GLACVCD to improve drainage within the influent trough (see Figure 2-3), a metal grid was placed above the weep holes. The metal grid appeared to improve drainage by preventing the weep holes from becoming clogged.	No abatement required.
IS2 I-210	GLACVCD	No breeding activity detected. However, the solids storage area below the double aluminum plate doors (see Figure 2-4) could not be accessed for inspection for stagnant water and/or potential vector problems. Mosquito breeding would be likely if water remains in the solids storage area and does not drain within a week.	No abatement required.
IS2 US-101	GLACVCD	No breeding activity detected. However, the solids storage area below the double aluminum plate doors (see Figure 2-4) could not be accessed for inspection for stagnant water and/or potential vector problems. Mosquito breeding would be likely if water remains in the solids storage area and does not drain within a week. Inspection reports note that the GSRD on a few occasions did not drain within the 72-hour target.	No abatement required.
BB I405	GLACVCD	No breeding activity detected. Inspection reports note that the GSRD on a few occasions did not drain within the 72-hour target.	No abatement required.
BB I-210	GLACVCD	No breeding activity detected. Inspection reports note that the GSRD on a few occasions did not drain within the 72-hour target.	No abatement required.

Section 5
Annual Gross Solids Loading and Capture Efficiency

5.1 GROSS SOLIDS DATA

The Phase I GSRDs Pilot Study monitored eight devices over the 2000-01 and 2001-02 storm seasons. During the 2000-01 storm season, the data collected consisted of measuring the wet weight and wet volume of the captured gross solids during interim and post season cleanings. For each device, the captured gross solids included the gross solids contained within the device, within the bypass bag, and within the overflow basket (if applicable). In addition to these measurements, the air-dried weight and air-dried volume were measured at the Caltrans Litter Laboratory. During the 2001-02 storm season, the data collected consisted only of measuring the wet weight and wet volume of the captured gross solids during interim and post season cleanings.

This section presents the data for the wet weight and wet volume of the captured gross solids during the 2000-01 and 2001-02 storm seasons. The air-dried weight and air-dried volume measurements collected during the 2000-01 storm season are presented and discussed in the Interim Report (Caltrans, 2001e). However, a summary of the air-dried weight and air-dried volume measurements is presented in Appendix A.

The total gross solids weight and volume collected at each GSRD site is presented in Table 5-1. The total gross solids measurement at each site includes the gross solids contained within the device, within the bypass bag, and within the overflow structure (if applicable). Table 5-1 also presents the number of cleanings required at each GSRD during each storm season. Table 5-2 summarizes the annual gross solids loading, normalized by area.

From Table 5-1, the total gross solids weight and volume measured at each site changed from the 2000-01 season to the 2001-02 season. This pilot study did not investigate the seasonal variability of gross solids deposition. Some possible reasons for the seasonal variation are listed below.

- Annual amount of rainfall
- Intensity and duration of storm events
- Amount of wind blown material deposited

As a result of the change in the total gross solids weight and volume at each site, the annual gross solids loading rate calculated at each site, presented in Table 5-2, also changed from the 2000-01 season to the 2001-02 season. The variability of the gross solids loading rate is discussed further in Section 6.7.1.

Table 5-1
Annual Wet Weights and Volumes of Gross Solids and Cleaning Performance

Site	2000-01			2001-02		
	Number of Cleanings	Total Wet Weight[1] kg (lb)	Total Wet Volume[2] m^3 (ft^3)	Number of Cleanings	Total Wet Weight[1] kg (lb)	Total Wet Volume[2] m^3 (ft^3)
LR1 I-10	**1**	111.9 (246.7)	0.40 (14.1)	**1**	172.7 (380.7)	0.65 (23.0)
LR2 I-210	**1**	410.2 (904.5)	1.10 (38.8)	**2**	1,310.0 (2,888.0)	1.73 (61.1)
LR2 I-5	**2**	191.6 (422.5)	0.20 (7.1)	**2**	197.4 (435.1)	0.19 (6.7)
IS1 SR-170	**1**	97.6 (214.7)	0.36 (12.7)	**1**	95.9 (211.4)	0.61 (21.5)
IS2 I-210	**2**	134.4 (296.4)	0.18 (6.4)	**1**	89.0 (196.2)	0.19 (6.7)
IS2 US-101	**2**	308.4 (680.0)	0.44 (15.5)	**2**	125.8 (277.3)	0.45 (15.9)
BB I-405	**2**	531.3 (1,171.5)	1.10 (38.8)	**2**	436.8 (963.0)	1.12 (39.6)
BB I-210	**2**	413.2 (911.1)	0.45 (15.9)	**1**	188.9 (416.5)	0.30 (10.6)

[1] Total wet weight includes the weight of gross solids captured within the device, within the bypass bag, and within the overflow structure (if applicable). The weight of gross solids was measured by placing each bag of collected gross solids on an electronic scale (see Section 4).

[2] Total wet volume includes the volume of gross solids captured within the device, within the bypass bag, and within the overflow structure (if applicable). The volume of gross solids was estimated by placing each bag of collected gross solids into a container of known volume. The gross solids were hand-leveled. The amount of freeboard was then measured and multiplied by the surface area of the container. This quantity was subtracted from the known volume to yield the estimated volume of gross solids (see Section 4).

For the 2000-01 storm season, the data in this report supercedes data in the Interim Report (Caltrans, 2001e).

Note: For reporting purposes, total wet weight for both S.I. units and U.S. Customary have been reported to the nearest tenth. Total wet volume in S.I. units has been reported to the nearest hundredth and to the nearest tenth in U.S. Customary units.

Table 5-2
Area-Normalized Annual Gross Solids Loading by Wet Weight and Volume

Site	Total Drainage Area ha (ac)	2000-01		2001-02	
		Weight per Unit Area kg/ha (lb/ac)	Volume per Area m^3/ha (ft^3/ac)	Weight per Unit Area kg/ha (lb/ac)	Volume per Area m^3/ha (ft^3/ac)
LR1 I-10	1.5 (3.7)	74.6 (66.7)	0.27 (3.8)	115.1 (102.9)	0.43 (6.2)
LR2 I-210	2.5 (6.2)	164.1 (145.9)	0.44 (6.3)	524.0 (465.8)	0.69[1] (9.9)
LR2 I-5	0.4 (0.9)	479.0 (469.4)	0.50 (7.1)	493.4 (483.4)	0.48 (7.4)
IS1 SR-170	1.0 (2.5)	97.6 (85.9)	0.36 (5.1)	95.9 (84.6)	0.61 (8.6)
IS2 I-210	1.4 (3.4)	96.0 (87.2)	0.13 (1.9)	63.6 (57.7)	0.14 (2.0)
IS2 US-101	0.8 (2.1)	385.5 (323.8)	0.55 (7.9)	157.2 (132.0)	0.56 (7.6)
BB I-405	1.2 (3.0)	442.8 (390.5)	0.92[1] (13.1)	364.0 (321.0)	0.93[1] (13.2)
BB I-210	0.9 (2.3)	459.1 (396.1)	0.50 (7.1)	209.9 (181.1)	0.33 (4.6)

[1] Approaches or exceeds the design value of 0.7 m^3/ha/yr (10 ft^3/ac/yr), presented in Section 2.3.

For the 2000-01 storm season, the data in this report supercedes data in the Interim Report (Caltrans, 2001e).

Note: For reporting purposes, total drainage area for both S.I. units and U.S. Customary has been reported to the nearest tenth. The weight per unit area for both S.I. units and U.S. Customary has been reported to the nearest tenth. The volume per unit area in S.I. units has been reported to the nearest hundredth and to the nearest tenth in U.S. Customary units.

5.2 CAPTURE EFFICIENCY

The gross solids capture efficiency was calculated by comparing the weight or volume of gross solids captured in the downstream bypass bag and overflow basket (if applicable) with the gross solids captured in the device:

$$\text{Capture Efficiency} = \frac{\begin{pmatrix} \text{Solids Caught} \\ \text{in GSRD} \end{pmatrix}}{\begin{pmatrix} \text{Solids Caught} \\ \text{in GSRD} \end{pmatrix} + \begin{pmatrix} \text{Solids Caught} \\ \text{in Bypass Bag} \end{pmatrix} + \begin{pmatrix} \text{Solids Caught} \\ \text{in Overflow Basket} \end{pmatrix}} \times 100\%$$

Capture efficiencies by volume for each device over the two storm seasons are presented in Table 5-3 and Figure 5-1. Additionally, capture efficiencies by weight for each device over the two storm seasons are presented in Table 5-4 and Figure 5-2. The volumes and weights presented in these tables and figures are the annual sum of the volumes and weights of gross solids captured within the device, within the bypass bag, and within the overflow basket, if applicable, during an entire storm season. Except for the IS1 SR-170, the capture efficiencies by volume and weight changed at each site from the 2000-01 season to the 2001-02 season. The change in capture efficiency at each site occurred without a change in operation of the GSRDs. It is not known why the capture efficiencies changed. As discussed in Section 4.3.2, the bypassed gross solids measured for the LR1 I-10 is believed to be windblown material. As a result, the LR1 I-10 should have had a calculated capture efficiency of 100 percent for both storm seasons.

The GSRDs were designed to meet the requirements of a full capture treatment system defined by the Los Angeles River Total Maximum Daily Load (TMDL) for trash. This TMDL defines a "full capture treatment system" as "*…any device or system that traps all particles retained by a 5 mm mesh screen and has a design treatment capacity of not less than the peak flow resulting from a one-year, one-hour storm (determined to be 0.6 inch per hour for the Los Angeles River watershed)*" (LARWQCB, 2001). The monitoring strategy employed for this study specified measuring the gross solids at the time cleanings were performed at each device, but not after every storm event. It is important to point out that, while the devices were designed to capture gross solids 5 mm or larger, the devices were observed to capture material smaller than 5 mm.

The pilot project study was not designed to determine the amount of gross solids that were bypassed on a per-storm event basis. Consequently, it is not possible to determine if the bypasses occurred during storm events greater than the design storm which would be allowed under the TMDL or less than the design storm which would violate the TMDL. Furthermore, it is not possible to tell whether the gross solids captured in the downstream bypass bag and overflow basket escaped the GSRD during bypass events or normal operations. The presumption is that these gross solids escaped only during high flows. However, in the case of IS2 I-210 and IS2 US-101, gross solids were observed to be forced through the screen under normal flows (Section 4.3.11). Whether this phenomenon occurred at the other GSRDs that bypassed gross solids (LR2 I-210, LR2 I-5, BB I-405, and BB I-210) and how many solids escaped in this manner is unknown.

Table 5-3
Gross Solids Capture Efficiency by Wet Volume

Site	2000-01				2001-02			
	Captured Gross Solids m^3 (ft^3)	Bypassed Gross Solids[1] m^3 (ft^3)	Total Gross Solids m^3 (ft^3)	Capture Efficiency (%)	Captured Gross Solids m^3 (ft^3)	Bypassed Gross Solids[2] m^3 (ft^3)	Total Gross Solids m^3 (ft^3)	Capture Efficiency (%)
LR1 I-10	0.39 (13.8)	0.01 [2] (0.4)	0.40 (14.1)	100 [2]	0.65 (23.0)	0.00 (0.0)	0.65 (23.0)	100
LR2 I-210	0.61 (21.5)	0.49 (17.3)	1.10 (38.8)	56	1.32 (46.6)	0.41 (14.5)	1.73 (61.1)	76[3]
LR2 I-5	0.18 (6.4)	0.02 (0.7)	0.20 (7.1)	90	0.19 (6.7)	0.00 (0.0)	0.19 (6.7)	100
IS1 SR-170	0.36 (12.7)	0.00 (0.0)	0.36 (12.7)	100	0.61 (21.5)	0.00 (0.0)	0.61 (21.5)	100
IS2 I-210	0.12 (4.2)	0.06 (2.1)	0.18 (6.3)	69[3]	0.19 (6.7)	0.00 (0.0)	0.19 (6.7)	100
IS2 US-101	0.34 (12.0)	0.10 (3.5)	0.44 (15.5)	77[3]	0.38 (13.4)	0.07 (2.5)	0.45 (15.9)	84[3]
BB I-405	0.96 (33.9)	0.14 (4.9)	1.10 (38.8)	87[3]	1.00 (35.3)	0.12 (4.2)	1.12 (39.5)	90[3]
BB I-210	0.43 (15.2)	0.02 (0.7)	0.45 (15.9)	97[3]	0.30 (10.6)	0.00 (0.0)	0.30 (10.6)	100[3]

[1] "Bypassed gross solids" is the amount of gross solids captured in the bypass bag and overflow basket (if applicable) at each GSRD.

[2] Material collected in the bypass bag is presumed to be wind blown.

[3] GSRD overflowed. Gross solids escaped the overflow structure and were unaccounted for. As a result, the calculated capture efficiencies are overstated.

For the 2000-01 storm season, the data in this report supercedes data in the Interim Report (Caltrans, 2001e).

Note: For reporting purposes, volume measurements in S.I. units have been reported to the nearest hundredth and to the nearest tenth in U.S. Customary units. This rounding may introduce small errors in the reported values.

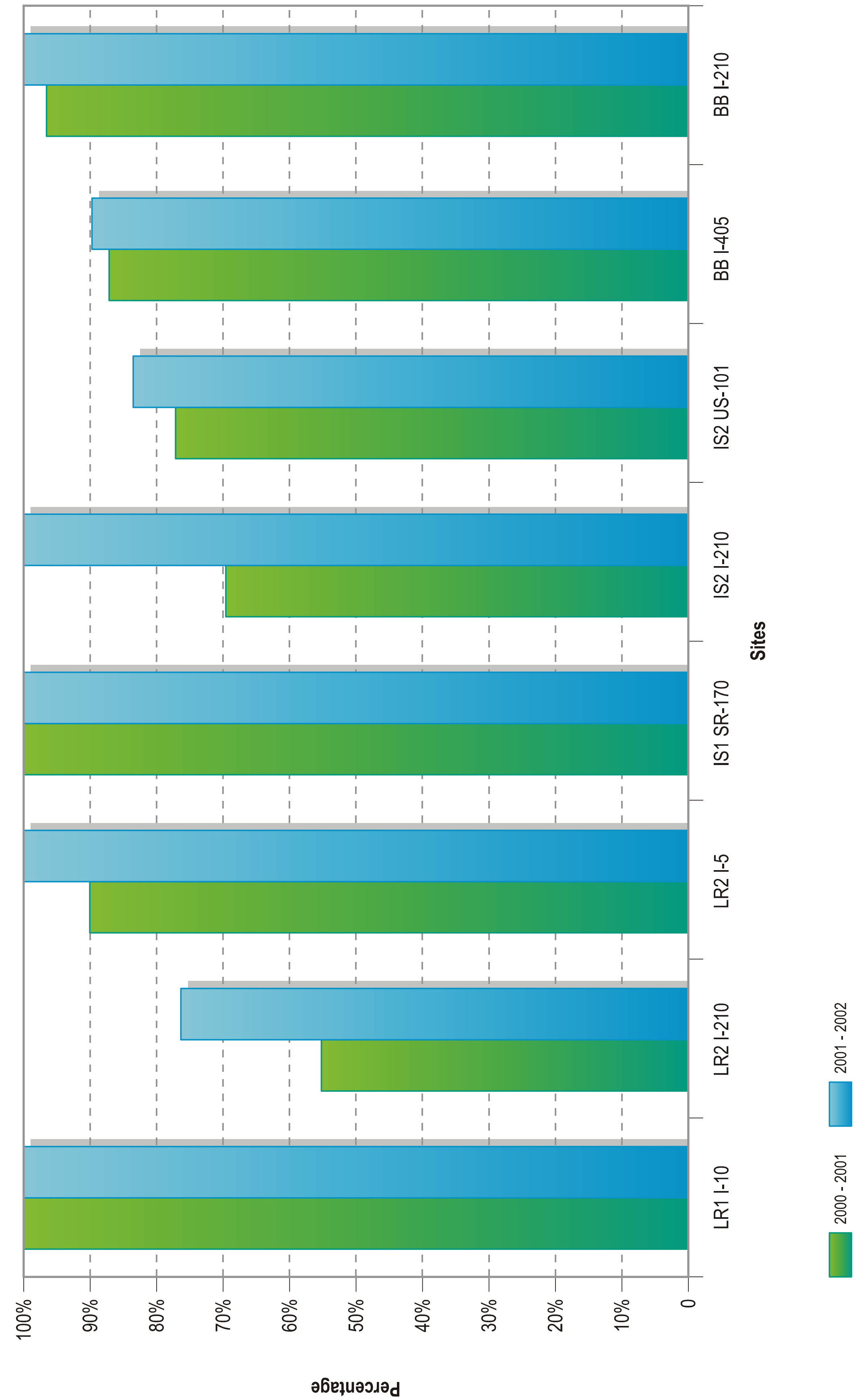


Figure 5-1
Gross Solids Capture Efficiency by Wet Volume

Table 5-4
Gross Solids Capture Efficiency by Wet Weight

Site	2000-2001				2001-2002			
	Captured Gross Solids kg (lb)	Bypassed Gross Solids[2] kg (lb)	Total Gross Solids kg (lb)	Capture Efficiency (%)	Captured Gross Solids kg (lb)	Bypassed Gross Solids[2] kg (lb)	Total Gross Solids kg (lb)	Capture Efficiency (%)
LR1 I-10	110.1 (242.7)	1.8 (4.0)	111.9 (246.7)	100[3]	172.7 (380.7)	0.0 (0.0)	172.7 (380.7)	100
LR2 I-210	398.0 (877.4)	12.2 (26.9)	410.2 (904.3)	97	1,146.0 (2,525.6)	164.4 (362.4)	1,310.0 (2,888.1)	87[1]
LR2 I-5	179.6 (395.9)	12.0 (26.5)	191.6 (422.4)	94	197.4 (435.2)	0.0 (0.0)	197.4 (435.2)	100
IS1 SR-170	97.6 (215.2)	0.0 (0.0)	97.6 (2,115.2)	100	95.9 (211.4)	0.0 (0.0)	95.9 (211.4)	100
IS2 I-210	111.2 (245.2)	23.2 (51.1)	134.4 (296.3)	83[1]	89.0 (196.2)	0.0 (0.0)	89.0 (196.2)	100
IS2 US-101	265.7 (585.8)	42.7 (94.1)	308.4 (679.9)	86[1]	91.8 (202.4)	34.0 (75.0)	125.8 (277.3)	73[1]
BB I-405	494.6 (1,090.4)	36.7 (80.9)	531.3 (1,171.3)	93[1]	422.3 (931.0)	14.5 (32.0)	436.8 (963.0)	97[1]
BB I-210	411.6 (907.4)	1.6 (3.5)	413.2 (911.0)	100[1]	188.9 (416.5)	0.0 (0.0)	188.9 (416.5)	100[1]

[1] GSRD overflowed. Gross solids escaped the overflow structure and were unaccounted for. As a result, the calculated capture efficiencies are overstated .

[2] "Bypassed gross solids" is the amount of gross solids captured in the bypass bag and overflow basket (if applicable) at each GSRD.

[3] Material collected in the bypass bag is presumed to be wind blown.

For the 2000-01 storm season, the data in this report supercedes data in the Interim Report (Caltrans, 2001e).

Note: For reporting purposes, weight measurements for both S.I. units and U.S. Customary has been reported to the nearest tenth. This rounding may introduce small errors in the reported values.

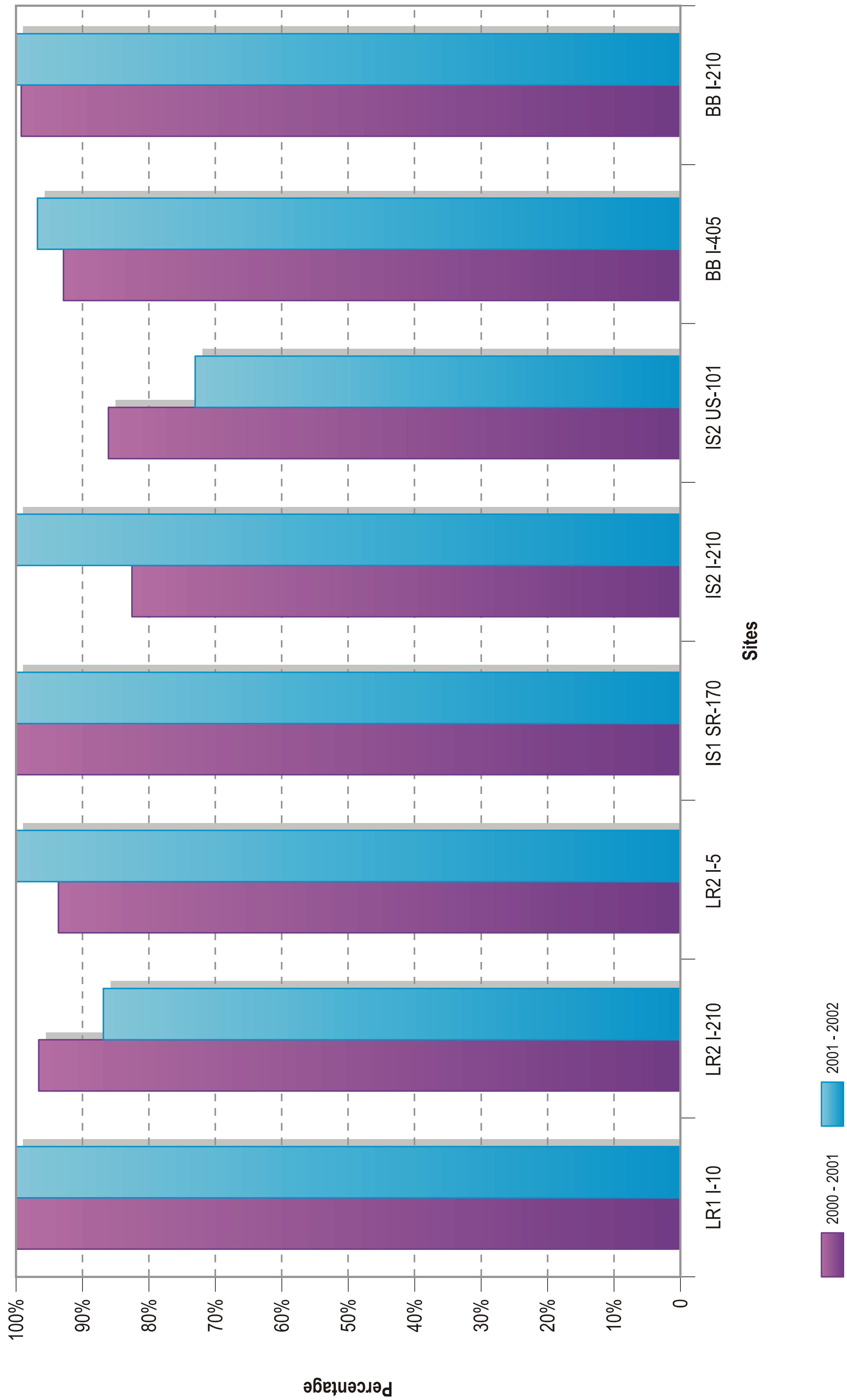


Figure 5-2
Gross Solids Capture Efficiency by Wet Weight

Section 6
Discussion and Summary

6.1 COMPLIANCE WITH TMDL

The California Regional Water Quality Control Board, Los Angeles Region (LA RWQCB) has developed a total maximum daily load (TMDL) that is designed to attain the water quality standards for trash in the Los Angeles River (LA RWQCB, 2001). A TMDL represents the total amount of a given pollutant that can be released into a water body consistent with the goal of restoring and ultimately maintaining beneficial uses designated for the water body. A waste load allocation (WLA) allocates this total maximum daily load among all dischargers of that pollutant to a particular waterway. The final WLA for the TMDL for trash in the Los Angeles River Watershed is set at zero and will be met over a period of 12 years through a phased reduction. This phased reduction means that Caltrans will retrofit a percentage of its outfalls that drain into the Los Angeles River Watershed each year until all the outfalls have been retrofitted within the time frame.

The TMDL regulation states that areas served by a full capture treatment system will be considered in compliance with the final WLA, provided that the full capture treatment system is adequately sized and maintained, and maintenance records are available for inspections by the LA RWQCB (LA RWQCB, 2001). The TMDL identifies the vortex separation system as an approved full capture treatment system. Other devices or systems, such as the eight GSRDs tested in this study, may be employed, but must be approved by the Executive Officer of the LA RWQCB before removal credit is granted. The criteria for a full capture treatment system are provided in Section 2.1 and in the next section.

6.2 OVERALL GSRD PERFORMANCE

The overall performance of each GSRD was assessed by evaluating how well the GSRD met the different design objectives listed in Section 2.1 and repeated below. The design objectives include four performance criteria established by the TMDL and Caltrans, and two additional performance goals set by Caltrans. A GSRD cannot be considered a success unless it meets all four performance criteria. Beyond this consideration, the extent to which a GSRD meets the two performance goals assesses its desirability as compared with another GSRD.

The following two performance criteria were set by the TMDL for an approved full capture treatment system:

C1	Particle Capture	The device or system must capture all particles retained by a 5 mm (0.2 in nominal) mesh screen from all runoff generated from a one-year, one-hour storm (determined to be 0.6 in [15 mm] per hour for the Los Angeles River Watershed).
C2	Clogging	The device or system must be designed to prevent plugging or blockage of the screening module.

The following two performance criteria were set by Caltrans:

C3	Hydraulic Capacity	The device or system must pass the Caltrans design flow. In District 7, this design flow is the 25-year peak flow.
C4	Drainage	The device or system must drain within 72 hours to avoid vector breeding.

Additionally, the following two performance goals were set by Caltrans:

G1	Gross Solids Storage Capacity	The device or system will hold the estimated annual load of gross solids, so that it requires only one cleaning per year.
G2	Maintenance Requirements	The device or system will not require any maintenance other than inspections throughout the storm season.

6.3 GSRD PERFORMANCE CRITERIA

The TMDL and Caltrans criteria represent design objectives for the pilot study that must be met by the eight GSRDs for consideration for future deployment.

6.3.1 Criterion C1 - Particle Capture

For this pilot study, the word "all" stated in the first TMDL criterion is interpreted to mean 100 percent of the particles at or greater than the targeted size. Furthermore, it is assumed that particles captured during one storm event are not allowed to be re-suspended and released back into the storm drain system by subsequent storms.

In this pilot study, particles retained by a 5 mm (0.2 in nominal) mesh screen are assumed to be the same as particles retained by a well casing with 5 mm x 64 mm (0.2 in x 2.5 in nominal) louvers, a 3 mm (0.125 in nominal) spaced parabolic wedge-wire screen, 5 mm (0.2 in nominal) spaced parabolic bars, or a slotted plate with 5 mm (0.2 in nominal) openings. This assumption was verified through observations, discussed in Section 4.3, for the well casing with 5 mm x 64 mm (0.2 in x 2.5 in nominal) louvers, the 3 mm (0.125 in nominal) spaced parabolic wedge-wire screen, and the 5 mm (0.2 in nominal) slotted plate. For the 5mm (0.2 in nominal) spaced parabolic bars, the bars were observed to capture the size of particles retained by a 5 mm (0.2 in nominal) mesh screen. However, as discussed in Section 5.2, gross solids were observed to be forced through the spacing of the bars.

Only one device, the IS1 SR-170, captured 100 percent of the gross solids during both storm seasons without operating under overflow conditions (see Table 5-3). The LR1 I-10 captured 100 percent of the gross solids during the 2001-02 storm season. During the 2000-01 storm season, 2 percent (by volume) of the gross solids were captured in the downstream bypass bag. However, based on the observations discussed in Section 4.3.2, it is thought that the gross solids in the bypass bag were blown there by the wind rather than carried there by water bypassing the GSRD. If true, the LR1 I-10 actually captured 100 percent of the gross solids during both storm seasons.

The measured capture efficiencies of LR2 I-210, IS2 US-101, BB I-405, and BB I-210 were each less than 90 percent. Even these values are overstatements because some gross solids escaped the system and weren't captured in the overflow/bypass bags when the GSRDs overflowed. This overflow condition happened to each device at least once during one or both storm seasons. As discussed in Section 5.2, it is presumed that the GSRDs bypassed gross solids or overflowed only in storms greater than the TMDL design storm. If this presumption is correct, then all eight GSRDs met the first criterion of the TMDL. In other words, gross solids capture during storm events less than or equal to the design storm was 100 percent.

6.3.2 Criterion C2 - Clogging

As discussed in Section 4.3.1, the LR1 I-10 had no observable problems with clogging or blinding. As discussed in Sections 4.3.2 and 4.3.3, the LR2 I-210 and LR2 I-5 had observable clogging throughout one or both storm seasons. To prevent the clogging, maintenance would be required periodically during a storm season.

As discussed in Section 4.3.9, the screen module in the IS1 SR-170 was observed to be self-cleaning. The screen modules in the IS2 I-210 and IS2 US-101 were observed to partially clog as each storm season progressed. Maintenance would be required periodically during a storm season for these devices. As discussed in Section 4.3.10, both baffle box GSRDs clogged frequently throughout each storm season. Maintenance would be required for these devices on a storm event basis to keep the GSRDs from clogging.

Only the LR1 I-10 and IS1 SR-170 would meet the second criterion of the TMDL without maintenance during the storm season. The remaining GSRDs could meet the criterion if a maintenance schedule were put in place to periodically remove sediment and other solids during the storm season.

6.3.3 Criterion C3 - Hydraulic Capacity

In general, each GSRD was designed to capture the estimated annual amount of gross solids and convey the Caltrans design flow. For this pilot study, the criteria in the Caltrans Highway Design Manual and local Caltrans district, District 7, required each GSRD to convey the 25-year peak flow. The purpose of this requirement is to prevent storm water from backing up onto the freeway. Because each GSRD was designed to safely bypass flows in excess of the 25-year peak flow, all eight GSRDs are presumed to meet this criterion.

6.3.4 Criterion C4 - Drainage

All of the GSRDs were also designed to drain within 72 hours to prevent vector breeding. As discussed in Section 4.3.4, one-time modifications were made to the IS1 SR-170 to provide screening above the weep holes to improve draining of the upper trough. Both the LR1 I-10 and IS1 SR-170 met the 72 hour drain time. The remaining GSRDs required maintenance throughout one or both storm seasons to remove sediment and other solids that contributed to the clogging and resulting standing water. The remaining GSRDs could meet the criterion if a maintenance schedule were put in place.

6.4 GSRD PERFORMANCE GOALS

The purpose of the two Caltrans goals was to reduce the maintenance effort, time, and equipment needed for each GSRD. The goals represent desirable features to maintain and operate the approximately 2,200 outfalls that will need to be retrofitted for compliance with the TMDL. As a result, GSRDs that do not meet the goals may not necessarily be disqualified, though they would not be preferred devices.

6.4.1 Goal G1 - Gross Solids Storage Capacity

Each GSRD was designed to capture the estimated annual load of gross solids, which would result in one cleaning per year. Both the LR1 I-10 and IS1 SR-170 met the goal of one cleaning per storm season, as shown in Table 5-1. The remaining GSRDs required two cleanings during one or both storm seasons.

There are two potential causes for the remaining GSRDs to have required more than one cleaning. First, the GSRD may have received a greater amount of gross solids than the design value of 0.7 m^3/ha (10 ft^3/ac). The BB I-405 required two cleanings each storm season. For each storm season, the annual amount of gross solids collected was greater than the design amount, as shown in Table 5-2. Therefore, it is possible that the GSRD could have met this goal if the gross solids storage area within the GSRD was sized adequately. Second, the screen may have clogged. As discussed in Section 4.2.2, a trigger for cleaning was the observation of extensive clogging or overflow. In Section 4, Table 4-1 lists the GSRDs that required an interim cleaning and the reason for the interim cleaning.

6.4.2 Goal G2 - Maintenance Requirements

During the two storm seasons, the LR1 I-10 was the only device that did not require any maintenance except for the end-of-season cleanings. The IS1 SR-170 required a one-time maintenance effort to improve drainage of the upper trough to reduce the presence of standing water. The IS1 SR-170 did not require any maintenance for clogging or blinding of the main screening module. Future designs of the Inclined Screen – Configuration No. 1 will remove the influent trough and solids trap.

The remaining GSRDs required maintenance during the one or both storm seasons to remove material clogging the devices. The baffle box GSRDs required the most effort to maintain throughout both storm seasons. The LR1 I-10 and IS1 SR-170 best meet the goal of requiring only inspections throughout the storm season.

6.5 SUMMARY EVALUATIONS

Table 6-1 summarizes how well each GSRD met the performance criteria and goals discussed in Sections 6.3 and 6.4. Table 6-2 summarizes the strong points, weak points, and potential to correct deficiencies, if applicable, of each GSRD. Overall, the LR1 I-10 and IS1 SR-170 performed the best of the eight GSRDs. These GSRDs met the criteria of the TMDL and Caltrans, and they best met the Caltrans goals. The LR1 I-10 and IS1 SR-170 are scheduled to be part of a full-scale hydraulics lab study. The purpose of the lab study is to characterize the hydraulic capacity of each GSRD to better understand how each device will operate hydraulically within the existing Caltrans storm drain system.

Table 6-1
GSRD Pilot Performance Summary in Relation to Design Criteria and Goals

Device	Criterion (C) or Goal (G)					
	C1 Particle Capture	C2 Clogging	C3 Hydraulic Capacity	C4 Drainage	G1 Solids Storage	G2 Maintenance Requirements
Linear Radial Configuration #1	Yes. Solids in the bypass bag during the first storm season presumed to be deposited by wind.	Yes.	Presumably. Device designed to pass 25-yr storm. An event equivalent to a 10 to 25-year, 24-hour, was observed during the study.	Yes.	Yes.	Yes.
Linear Radial Configuration #2	Possibly. Annual capture efficiency <90% but solids bypass thought to occur only in storms larger than the TMDL design storm.	No. Clogging observed.	Presumably. Device designed to pass 25-yr storm but such an event was not observed during the study.	No. Periodic maintenance needed to clear drainage fixtures.	Uncertain. Devices had to be cleaned more than once per year due to clogging and overflowing.	No. Maintenance required to unclog screens and drainage fixtures.
Inclined Screen Configuration #1	Yes.	Yes.	Presumably. Device designed to pass 25-yr storm. An event equivalent to a 10 to 25-year, 24-hour, was observed during the study.	Yes.	Yes.	Yes.
Inclined Screen Configuration #2	Possibly. Annual capture efficiency <90% but solids bypass thought to occur only in storms larger than the TMDL design storm.	No. Clogging observed.	Presumably. Device designed to pass 25-yr storm but such an event was not observed during the study.	No. Periodic maintenance needed to clear drainage fixtures.	Uncertain. Devices had to be cleaned more than once per year due to clogging and overflowing.	No. Maintenance required to unclog screens and drainage fixtures.
Baffle Box	Possibly. Annual capture efficiency <90% but solids bypass thought to occur only in storms larger than the TMDL design storm.	No. Clogging observed.	Presumably. Device designed to pass 25-yr storm but such an event was not observed during the study.	No. Periodic maintenance needed to clear drainage fixtures.	Uncertain. BB I-405 received more solids than the design amount. BB I-210 had to be cleaned more than once per year due to clogging and overflowing.	No. Maintenance required to unclog screens and drainage fixtures.

Table 6-2
Summary of Performance Characteristics for Each GSRD

Device	Strong Points	Weak Points	Potential to Correct Deficiencies
Linear Radial Configuration #1	▪ Met C1 (Particle Capture), C2 (Clogging), C4 (Drainage), G1 (Solids Storage, and G2 (Maintenance Requirements). ▪ Presumed to have met C3 (Hydraulic Capacity.	▪ Uncovered device allows wind-blown material into the concrete vault. The wind-blown material can enter the storm drain system following a storm event.	▪ Provide cover, for example, grating, for device.
Linear Radial Configuration #2	▪ Presumed to have met C1 (Particle Capture) and C3 (Hydraulic Capacity).	▪ Did not meet C2 (Clogging), C4 Drainage), and G2 (Maintenance Requirements). ▪ Not known if met G1 (Solids Storage)	▪ Increase size of device, that is, add more nylon mesh bags. *(Note: This statement cannot be supported without further research.)*
Inclined Screen Configuration #1	▪ Met C1 (Particle Capture), C2 (Clogging), C4 (Drainage), G1 (Solids Storage, and G2 (Maintenance Requirements). ▪ Presumed to have met C3 (Hydraulic Capacity.	▪ Weep holes in upper trough can easily plug.	▪ Provide metal grid above weep holes, as done for this study. ▪ Remove influent trough. *(Note: This statement cannot be supported without further research.)*
Inclined Screen Configuration #2	▪ Presumed to have met C1 (Particle Capture) and C3 (Hydraulic Capacity).	▪ Did not meet C2 (Clogging), C4 Drainage), and G2 (Maintenance Requirements). ▪ Not known if met G1 (Solids Storage)	▪ Increase size of device, that is, storage area and screen. *(This statement cannot be supported without further research.)* ▪ Relocate screen above litter storage area. *(Note: Generally becomes same design as IS1 SR-170.)* ▪ Reduce spacing of the bars from 5 mm (0.2 in nominal) to 3 mm (0.125 in nominal).
Baffle Box	▪ Presumed to have met C1 (Particle Capture) and C3 (Hydraulic Capacity).	▪ Did not meet C2 (Clogging), C4 Drainage), and G2 (Maintenance Requirements). ▪ Not known if met G1 (Solids Storage)	▪ Increase size of device, that is, storage area. *(This statement cannot be supported without further research.)*

6.6 REGIONAL BOARD APPROVAL

The GSRDs evaluated in this pilot study will need to be approved by the RWQCB's Executive Officer before they can be used to obtain credit towards meeting the WLA. Coordination with the RWQCB will be required to start the process of getting any of the proposed GSRDs approved. As mentioned in Section 6.5, the LR1 I-10 and IS1 SR-170 performed the best of the eight GSRDs. Additionally, as shown in Table 6-2, these two devices met the criteria of a full capture treatment system. The criteria of a full capture treatment system are defined in Section 2.1.

6.7 ADDITIONAL PILOT STUDY OBSERVATIONS

6.7.1 Gross Solids Loading Rate

The estimated annual gross solids loading by volume for design was 0.7 m^3/ha (10 ft^3/ac). This design number was applied to all eight sites so that each GSRD would need to be cleaned only once per storm season. When the estimated annual loading of gross solids is exceeded at a site, additional cleanings may be required. This exceedance occurred at BB I-405. This device required two cleanings each year. However, as listed in Table 4-1, the cleanings were triggered because of observed clogging and overflow. If the device had not experienced clogging and overflow, two cleanings per year would still have been required since the estimated annual loading of gross solids was exceeded.

Over the two storm seasons, seven out of the eight sites exhibited annual gross solids loadings that were less than the estimated annual gross solids loading of 0.7 m^3/ha (10 ft^3/ac) (Table 5-2). What is interesting is the range of annual gross solids loadings observed, from 0.13 m^3/ha (1.9 ft^3/ac) to 0.92 m^3/ha (13.1 ft^3/ac), almost an order of magnitude. Table 5-2 also shows some surprising changes from year to year. For instance, at IS1 SR-170, the annual gross solids loading in the 2001-02 season was almost twice the annual gross solids loading in the 2000-01 season; while at BB I-210, the annual gross solids loading in the 2001-02 season was approximately 30 percent less than the annual gross solids loading in the 2000-01 season.

Due to these variations in calculated annual gross solids loading for each GSRD, further investigation and refinement of the estimated annual gross solids loading for design may be warranted to meet the target of one cleaning per storm season. Additionally, designs that are easily expanded in the field should be investigated due to the variations in annual gross solids loading.

6.7.2 Proposed GSRD Inspection Frequency

GSRDs that are deployed to comply with the TMDL should be inspected on a regular basis. The inspection schedule for these GSRDs should be as follows:

- One inspection 30 days prior to the beginning of the rainy season. The rainy season is defined as October 1 through May 1.
- A few inspections during the rainy season. Preferably, these interim inspections should be conducted after a rain event of 25.4 mm (1 in) or greater. In Southern California, the inspection frequency would average between two to three times per year.

- One inspection at the end of the rainy season in conjunction with the annual cleaning.

Inspections should consist of visual observations of the amount of gross solids collected in the devices, noting any obvious obstructions to the hydraulic capability of the devices, verifying that the devices are properly draining following rain events, and observations related to site security (e.g., fences in place, gates locked, and no graffiti on the device).

6.7.3 Overall GSRD System

The Phase I GSRDs Pilot Study focused only on the design of non-proprietary collection devices, which is only one of three components of the overall Gross Solids Collection System. The three components of the Gross Solids Collection System are listed below:

1. On-Site Collection
2. Inspections and Maintenance
3. Solids Disposal

On-Site Collection includes non-proprietary devices that can capture gross solids to meet the requirements of the TMDL and the requirements and goals of Caltrans. This component has been the focus of this pilot study. The second component, Inspections and Maintenance, ensures that the devices continue to capture gross solids throughout each storm season, convey storm water runoff away from the roadway, and collect the captured gross solids for disposal. In the third component, Solids Disposal, the collected gross solids are transported from the collection device to the appropriate disposal site.

This study has not considered how the overall system would operate once all of the approximately 2,200 GSRDs were installed within the watershed. A number of issues within the overall system remain to be addressed in future studies. One issue that affects the design of GSRDs is site access and is discussed below.

6.7.3.1 Site Access

This study utilized sites with sufficient access for construction equipment, monitoring vehicles, and cleaning vehicles. It is likely that many sites within the watershed will not have sufficient access for construction equipment and cleaning vehicles. Sites with limited access will dictate the type of cleaning vehicle that can be used which in turn affects design. For example, if a Vactor Truck can not access a site due to height restrictions, a GSRD that can only be cleaned by a Vactor Truck would not be appropriate. This issue has not played an important role to date in establishing design criteria and goals. An examination of site characteristics and problems may be warranted to determine their effects on future designs.

Section 7 References

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Caltrans, 2001d. Caltrans. Statewide Storm Water Management Plan. August 2001. CTSW-RT-01-024

Caltrans, 2001e. Caltrans. Gross Solids Removal Device (GSRD) Pilot Study 2000-2001 Interim Report. August 2001. CTSW-RT-01-047.

LA RWQCB, 2001. California Regional Water Quality Control Board – Los Angeles Region [LA RWQCB]. Trash Total Maximum Daily Loads for the Los Angeles River Watershed. September 19, 2001.

Appendix A
Initial Lab and Air-Dried Measurements (2000-2001)

The weights and volumes of the litter collected in the GSRDs through the 2000-01 season are presented in Table A.1. Gross solids collected from the GSRDs were analyzed using the guidelines from the Caltrans Litter Laboratory Analysis Method.

Table A-1
Initial and Air-Dried Litter Measurements for 2000-01

Site	Initial Lab [1] Weight kg (lb)	Initial Lab [1] Volume m^3 (ft^3)	Air-Dried Weight kg (lb)	Air-Dried Volume m^3 (ft^3)
LR1 I-10	14.2 (31.3)	0.14 (4.9)	9.7 (21.4)	0.12 (4.2)
LR2 I-210	10.0 (22.0)	0.10 (3.5)	6.6 (14.5)	0.05 (1.6)
LR2 I-5	8.1 (17.8)	0.04 (1.4)	6.2 (13.6)	0.04 (1.2)
IS1 SR-170	30.7 (67.6)	0.19 (6.7)	16.7 (36.8)	0.21 (7.4)
IS2 I-210	5.8 (12.8)	0.03 (1.1)	6.2 (13.6)	0.03 (1.1)
IS2 US-101	14.5 (31.9)	0.14 (4.9)	10.0 (22.0)	0.13 (4.6)
BB I-405	43.2 (95.0)	0.22 (7.8)	29.8 (65.6)	0.22 (7.8)
BB I-210	8.3 (18.3)	0.05 (1.8)	20.1 (44.2)	0.03 (1.2)

[1] The initial lab measurement represents the measurement at the laboratory after the field measurement, but prior to the air-dried measurement. In the Interim Report (Caltrans 2000e), this data is referred to as Wet Weight and Wet Volume.

For the 2000-01 storm season, the data in this report supercedes data in the Interim Report (Caltrans, 2001e).

Note: For reporting purposes, air-dried and initial lab weight measurements for both S.I. units and U.S. Customary has been reported to the nearest tenth. Air-dried and initial lab volume measurements in S.I. units have been reported to the nearest hundredth and to the nearest tenth in U.S. Customary units.