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## KEEP IT FLOWING – BYPASS STATION INSTALLATION ON A 35-YEAR OLD FORCE MAIN

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**ABSTRACT:** The Granada Force Main is part of the sewage transmission system operated by the Sewer Authority Mid-Coastside in Half Moon Bay. It is a 1.7-mile long, 14-inch-diameter, ductile iron pipe that conveys flows up to 3,000 gallons per minute (gpm) and pressures up to 60 pounds per square inch (psi). The 35-year old pipe has no access manways or isolation valves and needs extensive repair. It can only be shut down for a few hours. Installing a parallel redundant force main is not an acceptable option. Under such constraints, a customized approach has been developed to address immediate repair needs and allow future inspection and maintenance. The priority section of force main has been identified and repaired using Cured-In-Place Pipe (CIPP). Four bypass stations have also been installed along the non-rehabilitated portion of force main to afford Operations Staff opportunities for periodic inspections, maintenance, and repairs. The project required eleven force main shutdowns and had no sewage spills.

### 1. PROJECT SUMMARY

This technical paper presents the key findings of the project summarized in Table 1.

**Table 1. Project Summary Table**

<b>Title</b>	Granada Force Main Repair Project
<b>Location</b>	EI Granada and Half Moon Bay, San Mateo County, California
<b>Dates</b>	January 2012 – September 2013
<b>Owner</b>	Sewer Authority Mid-Coastside (SAM)
<b>Design Engineer Construction Manager</b>	SRT Consultants (SRT)
<b>General Contractor</b>	Anderson Pacific Engineering Construction (APEC)
<b>Construction Cost</b>	\$1,300,000
<b>Issues to Resolve</b>	<ol style="list-style-type: none"><li>1) Replace or rehabilitate the priority sections of the force main</li><li>2) Provide means for future inspection and repair of the force main</li><li>3) Replace all air release valves and vacuum break valves</li></ol>
<b>Project Content</b>	<ol style="list-style-type: none"><li>1) Rehabilitation of 1,450 feet of force main using Cured-In-Place Pipe</li><li>2) Construction of four bypass stations</li><li>3) Replacement of all air release valves and vacuum break valves</li></ol>

## **2. INTRODUCTION**

The SAM's Intertie Pipeline System (IPS) is a transmission system composed of pump stations, force mains (FMs), and gravity interceptors that conveys raw sewage to SAM's Wastewater Treatment Plant located in Half Moon Bay, California. The IPS's two largest FMs are the Montara FM and the Granada FM. These FMs are 35 years old and constructed of bituminous-coated ductile iron. Neither pipeline has interior access ports or in-line isolation valves. They can only be shut down for a few hours at a time before their respective pump stations will overflow. The two FMs have recently experienced several leaks. Four of them resulted in Sanitary Sewer Overflows. All leaks were due to holes in the pipe wall and have been repaired using repair clamps.

In January 2012, a small hole on the Granada FM caused a leak that reportedly exceeded 2,500 gallons. Unfortunately, the spill discharged to a nearby public beach forcing temporary closure until the contamination level was diffused. Immediately after the event, SAM assigned two major objectives to their consulting engineer, SRT:

1. Preventatively repair priority sections of the Granada FM before the next wet weather season, i.e. the six-month period starting mid-October.
2. Design FM bypass stations that will provide Operations Staff access to the FM for future inspection and maintenance.

Installing a second parallel FM was not an acceptable option. The Montara FM was not included in the project scope.

## **3. FM SECTIONS IN IMMEDIATE NEED OF REPAIR**

The initial task consisted of locating the FM sections in immediate need of repair. FM sections were prioritized based on multiple criteria including recent FM leaks, surge pressures, staff safety, potential environmental impacts and traffic disturbance. Only limited information was available.

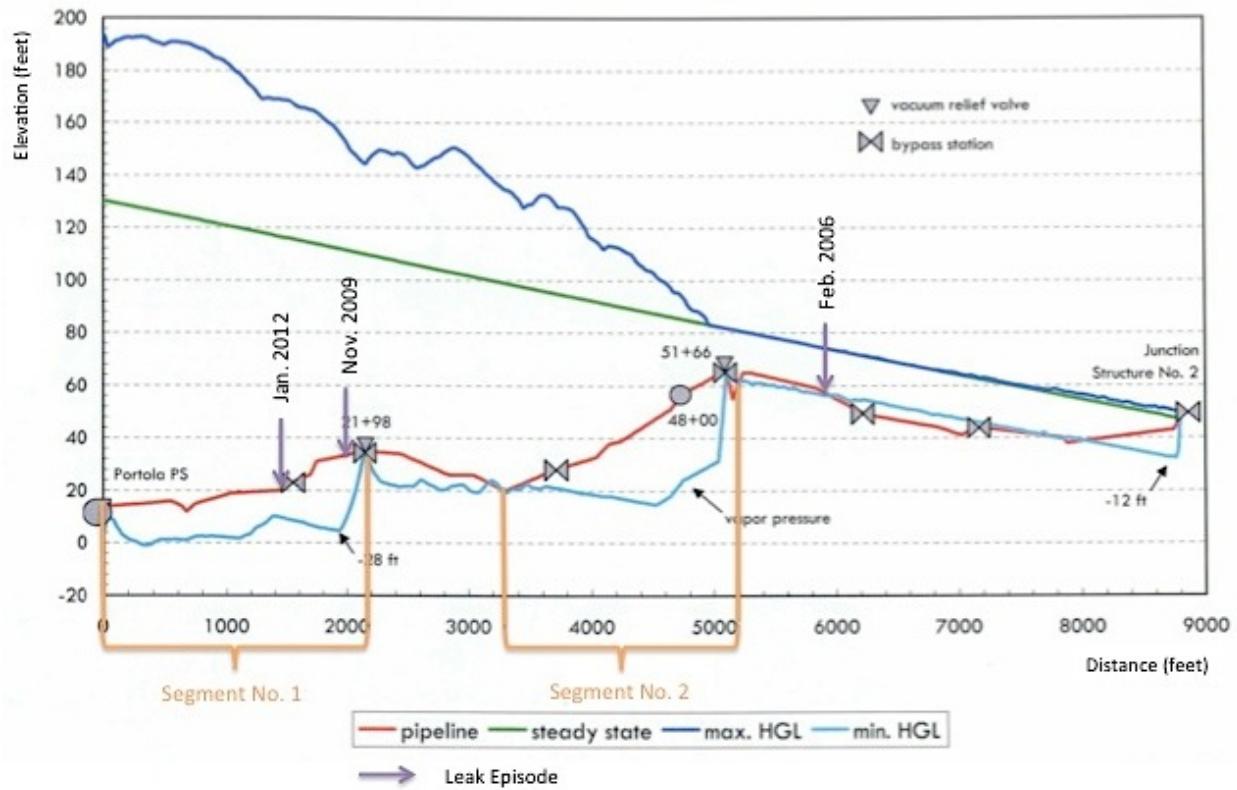
Staff records listed three recent leak episodes for the Granada FM: February 2006, November 2009, and January 2012. The leak sites are shown on Figure 1 (located on next page). Two of the three leaks (2009 and 2012) occurred immediately downstream of the Portola Pump Station. The origins of the 2006 and 2012 leaks were not investigated. The 2009 leak study performed by Winzler & Kelly identified corrosion triggered by sediment impingement as the probable cause of the quarter-sized hole found on the pipe invert. SRT later determined that the minimum scouring velocity of 2 to 3 feet per second is only achieved during high flows caused by heavy rainstorms.

SRT also determined that surge protection within the FM was insufficient. Flow Science was retained to perform a surge pressure analysis of the FM. Figure 1 (located on next page) shows the FM profile and the hydraulic grade line (HGL) elevations. Flow Science determined that two FM segments can experience high vacuum pressures following loss of power at Portola Pump Station:

1. Segment No. 1 – From Portola Pump Station (STA 0+00) to the first high elevation point (STA 22+00).
2. Segment No. 2 – The rising portion of FM to the highest elevation point from STA 33+00 to STA 52+00.

High vacuum pressures can potentially cause collapse within the FM. It was later determined that the combination air release and vacuum break valves were in various states of disrepair, compounding the problems identified by Flow Science. Based on Flow Science's recommendations, SAM requested (1) the replacement of the vacuum break valves with larger valves under the same project, and (2) the replacement of the existing malfunctioning surge tank as part of a separate project.

With the limited information available, Segment No. 1 appears at risk of undergoing the wear associated with sediment impingement and repeated high vacuum pressures over time.



**Figure 1: Granada FM Profile, HGL Elevations Envelope, and Recent Leak Sites**

The following additional risk factors were considered as criteria to define the FM priority sections:

1. Safety risk – vicinity of a PG&E high-pressure gas main. Segment No.1 is parallel to a PG&E 8-inch-diameter, high-pressure gas main from STA 2+50 to STA 17+00, whereas Segment No.2 does not;
2. Environmental risk – proximity to the Pacific Ocean. The Segments No.1 and No. 2 are 300 and 1,000 feet from the shore, respectively;
3. Traffic risk – potential for traffic disturbance during emergency repair. Segment No. 1 crosses Coronado Street, one of the only two accesses to the El Granada community from Highway 1 that experiences heavy commute traffic. The remainder of the FM is located in the open area on the northeast side of Highway 1 (Caltrans Right-Of-Way). The FM crosses several streets and driveways perpendicular to Highway 1, but none are as critical to traffic as Coronado Street.

Figure 2 (located on the next page) shows the section of FM between STA 2+50 and STA 17+00, which bears all aforementioned risk factors.



**Figure 2: FM Section between STA 2+50 And STA 17+00**

Different replacement and rehabilitation alternatives were studied for the selected section. Installing a new pipe parallel to the existing one was not an acceptable option. Replacing the existing pipeline in-place was not an acceptable option either, because it would have required excavating near a PG&E gas main and other buried utilities. Among available trenchless technologies, Cured-In-Place Pipe (CIPP) was preferred to limit the FM diameter reduction and preserve its hydraulic capacity.

As a result of this alternatives analysis, the following items were included in the construction project:

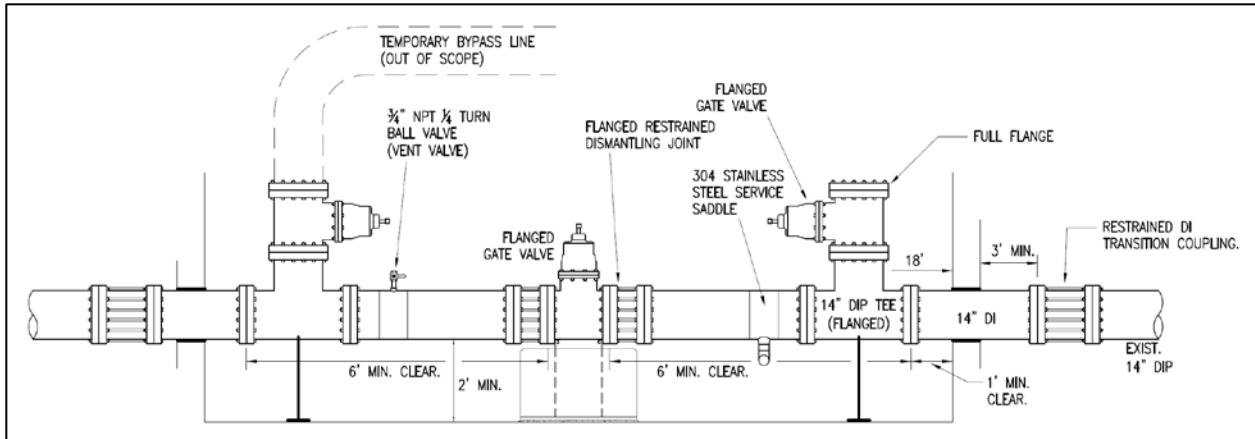
1. Rehabilitation using CIPP of the FM segment between STA 2+50 and STA 17+00;
2. Replacement of all air release valves; and
3. Replacement of the two existing 2-inch vacuum break valves with two 4-inch combination air release/vacuum break valves.

#### 4. BYPASS STATIONS DESIGN

Four bypass stations were also installed under this project along the 1.3-mile non-rehabilitated portion of FM. These stations will allow Operations Staff access to the inside of the FM for periodic inspections, maintenance, and repairs. Bypass stations are custom 18' x 6' precast concrete vaults. Existing pipe depth dictates their height. Figure 3 (located on next page) presents the typical bypass station mechanical assembly. The mechanical design includes the following items:

1. One isolation (in-line) valve, with a structural support designed to restrain the thrust when the valve is closed;
2. Two vertically mounted valves that allow by-pass pipes to be connected to the FM in the event of a rupture upstream or downstream of the station;
3. Two dismantling joints for piping disassembly on each side of the isolation valve;
4. Clearances on each side of the isolation valve allowing the bypass station to be used as a launching/receiving pit for future inspection and repair; and
5. One blow-off valve for FM drainage.

Where required, air release valves and vacuum break valves can be installed in the bypass station.



**Figure 3: Typical Bypass Station Mechanical Assembly Design**

The locations of the major improvements are shown on Figure 4.



**Figure 4: Location of Improvements along The Granada FM**

## 5. REHABILITATING THE FM SEGMENT USING CIPP

Figure 5 shows the general layout of the temporary facilities deployed by Contractor to bypass sewage prior to installing the Cured-In-Place Pipe.

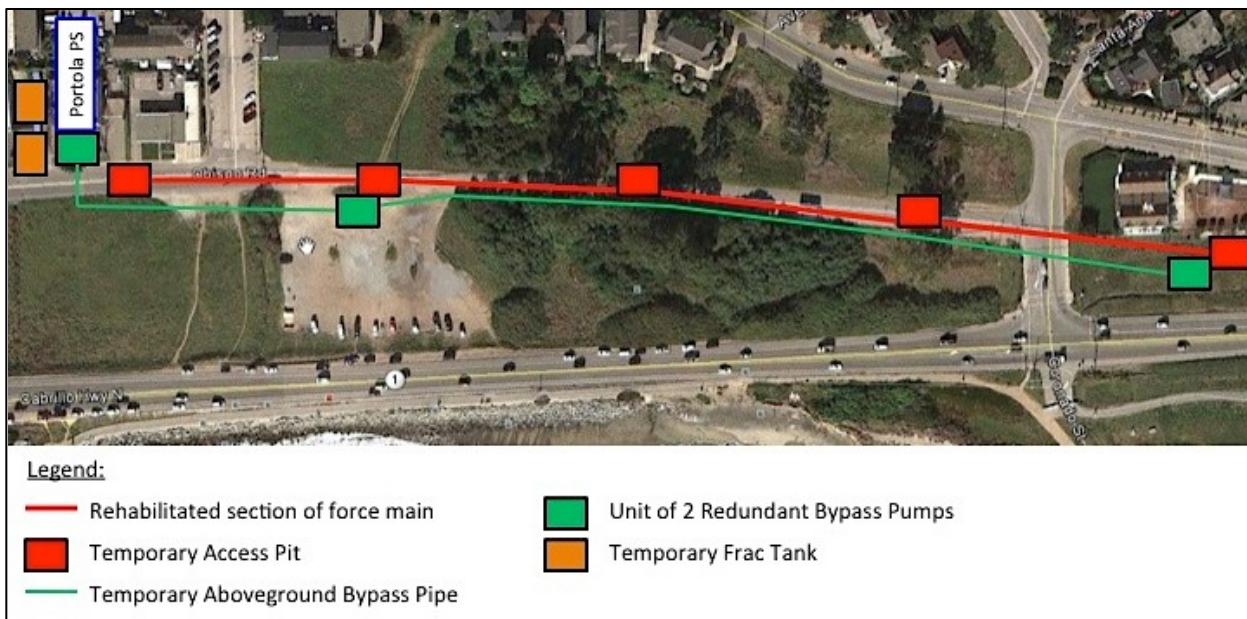


Figure 5: Temporary Sewage Bypass for CIPP

The project's construction sequence was generally as follows:

- Step 1: Install temporary bypass pipe and pumps;
- Step 2: Excavate five temporary access pits;
- Step 3: Start sewage bypass per following subsequence:
  - 3a: Shut down Portola Pump Station;
  - 3b: Drain FM into Portola wet well and temporary additional storage tanks;
  - 3c: Remove section of FM at STA 17+00, install temporary tie-in, and connect bypass pipe;
  - 3d: Start bypass pumping.
- Step 4: Clean and inspect FM using Closed-circuit Television (CCTV);
- Step 5: Install CIPP;
- Step 6: Inspect rehabilitated FM using CCTV;
- Step 7: Stop sewage bypass per following subsequence:
  - 7a: Shut down bypass pumps;
  - 7b: Drain bypass pipe and FM downstream STA 17+00 into Portola wet well and temporary additional storage tanks;
  - 7c: Remove temporary tie-in at STA 17+00 and reinstate FM connection;
  - 7d: Restart Portola Pump Station.
- Step 8: Remove temporary facilities.

Steps 3 and 7 required interrupting sewage conveyance for a few hours to connect and disconnect the temporary bypass pipe to the existing FM, respectively. These steps presented the greatest risk of causing a sewer spill. Specific measures were taken to mitigate the spill risk including: (1) work only during low flow periods, from 10 p.m. to 5 a.m.; (2) use vactor trucks to continuously remove sewage accumulating in wet well; and (3) start cutting into the existing FM no later than 1 a.m., as piping work was estimated to last 4 hours.

Figures 6 through 9 illustrate the steps of the sewage bypass system.



**Fig. 6: Step 1 – Bypass Pumps and Tanks**



**Fig. 7: Step 1 – 12-inch HDPE Bypass Pipeline**



**Fig. 8: Step 2 – Temporary Access Pits**



**Fig. 9: Step 3 – Bypass Tie-In**

Figures 10 through 17 illustrate the on-site preparation of CIPP and its installation.



**Fig. 10: Felt Liner**



**Fig. 11: Impregnation of Liner with Epoxy**



Fig. 12: Impregnation Control



Fig. 13: Impregnated Felt is Kept Refrigerated



Fig. 14: Liner Transferred to Pressure Vessel



Fig. 15: Liner Wound onto an Internal Spool



Fig. 16: Liner Insertion



Fig. 17: Steam is Introduced, Epoxy Cures

CCTV inspection prior to rehabilitation showed that the interior 3/16-inch bituminous coating was missing in several locations at the pipe invert.

## 6. CONSTRUCTING THE BYPASS STATIONS

The construction of the bypass stations was challenging since there was only a 10-foot wide easement on Caltrans Right-of-Way and PG&E high voltage overhead power lines that prohibited use of a crane. The Contractor initially contemplated to remove the FM section and replace it with a preassembled precast vault during one shut down. Lifting such a vault would have required a 60-ton crane with a 60-foot high boom. Potholing revealed the horizontal distance between FM and overhead power lines is less than 10 feet. As OSHA Regulation 1926.1408 prohibits operating a crane within a 10-foot radius of power lines up to 50 kilovolts, the option was abandoned.

The Contractor instead used a Komatsu PC400 large excavator that could be operated 10 feet below the overhead lines at all time. As the equipment lifting capacity was limited to 27,000 pounds, Contractor took the following additional measures:

1. The vaults were split in lighter sections;
2. Vault sections and mechanical pieces were handled one-by-one and assembled in place; and
3. Sewage was temporarily bypassed when assembling the bypass stations.

Figures 18 through 25 illustrate the sequence of construction of each bypass station.



Fig. 18: FM Drainage



Fig. 19: Temporary Bypass Setup



Fig. 20: Subgrade Preparation



Fig. 21: Vault Slab and Wall Installed



Fig. 22: Piping Installed



Fig. 23: Sealant Installation



Fig. 24: Vault Exterior



Fig. 25: Completed Vault Interior

The eight shutdowns required to install the bypass stations were performed successfully without any sewage spills. These shutdowns and associated FM drainages also presented a unique opportunity to inspect the pipe interior for the first time in 35 years. Such inspection was carried out using CCTV and revealed significant corrosion damages to the pipe invert along Segment No. 2 as shown on Figure 26. The origin of these damages has not been fully investigated at this time, Cavitation is most likely the cause. The new bypass stations will be utilized when SAM elects to repair or replace these damaged sections of the FM.



Fig. 26: Invert Damage at STA 51+50



Fig. 27: FM Has Slid a Little

## 7. LESSONS LEARNED DURING CONSTRUCTION

Construction occurred smoothly and as planned, but some items proved more challenging in the field than anticipated during design. The following are a few examples.

The first time the Portola Pump Station was shut down, the Contractor ran out of time when draining the FM. Work was stopped before FM was cut and the work was rescheduled to the next night. The decision avoided critical work being performed under time pressure during peak flow and was based on understanding the operational needs and construction constraints. The next night, work was successfully performed.

The logistics between the General Contractor and several sub-contractors involved in bypassing flow and installing the CIPP liner also proved challenging. Several incorrect items were identified in the by-pass pumping plan but were remedied in the field prior to putting the bypass pumps in service.

To accelerate the project, the FM was potholed by the Contractor during the construction phase not during the design phase. The design was based on the 35-year-old as-builts, which significantly misrepresented the horizontal and vertical alignment in several key locations.

Draining the contents of the FM was a challenge at each by-pass vault location. Working closely with SAM and the Contractor, creative solutions were developed to empty the pipeline including draining back to the pump station, using emergency wet weather storage tanks, hot-tapping the FM and draining by vactor truck.

## 8. NEXT STEPS

The newly constructed bypass stations have not yet been used by Operations Staff, but will be critical assets needed to perform the necessary repairs to the FM. SAM plans to rent the bypass pipe when needed. HDPE appears to be the preferred bypass pipe material for bypassing sections of the FM. Several rental companies should also soon supply 12-inch lay-flat hose, which could be used in this application.