Monitoring and Laboratory Division
Vapor Recovery and Fuel Transfer Branch
Vapor Recovery Regulatory Development Section

Project Number: VR-11-11
Report Number: VR-OP-G2

Overpressure Study

DRAFT

Technical Support Document

2013/2014 Field Study to Determine the Extent of the Overpressure Issue Occurring at California Gasoline Dispensing Facilities (Mega Blitz of 2013/2014)

December 7, 2017

TABLE OF CONTENTS

List of Tables

List of Figures

I. Executive Summary

Beginning in 2008, California Air Resources Board (CARB) staff became aware of wintertime In-Station Diagnostic (ISD) overpressure alarms which were not attributed to vapor recovery equipment failures. This prompted CARB staff to initiate a series of field studies, form workgroups, and issue advisories to deal with the problem. One such field study is known as the "Mega Blitz of 2013/2014" and involved collection of ISD data from nearly 400 gasoline dispensing facilities (GDF) throughout California and the GDF operating characteristics. ISD data was collected at each GDF during four separate periods: once in the fall before Reid Vapor Pressure (RVP) of gasoline changes; twice during the winter when high RVP gasoline is sold; and once in the spring when RVP returned to a regulated level.

Upon collection and assembly of information into a centralized database, staff analyzed instances of ISD overpressure alarms and the occurrence of a new phenomenon called pressure-while-dispensing (PWD) in order to determine frequency and severity of the issue. The data collected also provided information on system leaks. Of the nearly 400 GDFs surveyed, 69 percent were equipped with the Healy Assist Phase II EVR System and 31 percent were equipped with either the Vapor Solutions Technologies, Inc. (VST) or EMCO Wheaton Retail (EMCO) Balance Phase II EVR system. For the entire sample population, 55 percent of GDFs experienced one or more wintertime overpressure alarms. For those GDF equipped with the Assist Phase II EVR system, 70 percent experienced one or more winter time ISD overpressure alarms and 34 percent exhibited PWD. For those GDF equipped with the Balance Phase II EVR system, only 20 percent experienced one or more wintertime overpressure alarms and none exhibited PWD. PWD is of concern because it indicates that gasoline vapors are being emitted from the GDF directly to atmosphere. Staff also analyzed the data for frequency of ISD leak alarms. Approximately 9 percent of GDF equipped with Assist Phase II EVR systems experienced one or more leak alarms with winter blend gasoline. Approximately 33 percent of GDF equipped with Balance Phase II EVR systems experienced one or more leak alarms with winter blend gasoline.

The study revealed that the causes of overpressure are complex and are the result of a number of factors rather than a single variable. While winter blend gasoline (high RVP) is the primary cause of overpressure issues, nozzle type, GDF operating hours, monthly throughput, and excess air ingestion at the nozzle (vapor to liquid ratio of the assist nozzle) are key contributors to the problem. To address GDF overpressure, there will likely need to be a menu of solutions that are tied to GDF operational characteristics, addressing assist nozzle vapor to liquid ratio issues, vehicle fill pipe design, requiring additional processing capacity for GDFs with significant overpressure issues, and modification of ISD alarm thresholds. The study showed that the frequency of overpressure alarms is increasing every winter and that a range of solutions is needed to address the problem.

While the Mega Blitz of 2013/2014 provided valuable insight into the overpressure problem, at the conclusion of this study, it was determined that further study was needed. Staff recommended an Assist Nozzle On-Board Refueling Vapor Recovery (ORVR) Vehicle recognition study; the quantification of vent line and fugitive emissions from assist sites with PWD; the quantification of emissions from positive pressure at balance sites; and work with internal and external stakeholders to determine if vehicle fill pipe and nozzle specifications should be amended to ensure compatibility.

II: Introduction

Between October, 2013 and April, 2014, California Air Resources Board (CARB) staff conducted a statewide field study, referred to as the "Mega Blitz of 2013/2014," which involved manual collection of In-Station Diagnostic (ISD) system alarm history data, ISD generated pressure and ullage data, ISD generated individual fueling transaction data, and general operating characteristics from approximately 400 gasoline dispensing facilities (GDF) throughout the State of California. The objective of the field study was to determine the frequency and causes of ISD overpressure alarms and the prevalence of GDF which exhibit pressure-while-dispensing (PWD) during winter-time months.

Background

ISD systems are designed to provide continuous real time monitoring of critical gasoline vapor recovery system parameters and components, and to alert the operator when a failure mode, as defined in CARB regulations (title 17, California Code of Regulations, section 94010), is detected so that corrective action can be taken expeditiously. ISD systems record two types of gasoline vapor recovery system failure alarms. The first failure alarm will notify the GDF owner/operator of a potential vapor recovery system problem that requires maintenance. If the required corrective action is not taken within the specified time, the ISD system will trigger a second failure alarm and will terminate all fuel dispensing or specified fueling points depending upon the type of alarm.

Evaluation of in-use ISD systems demonstrates that ISD systems are effective year round in reducing gasoline vapor emissions through early identification of vapor recovery performance degradation. Thus, ISD delivers important air quality and health benefits. However, in 2008, CARB staff became aware of overpressure alarms that were not associated with enhanced vapor recovery (EVR) equipment failure and indicated that the headspace of the GDF underground storage tank (UST) was held at positive pressure for an excessive amount of time. Most overpressure alarms occur during a winter timeframe, when there is no Reid Vapor Pressure (RVP) limit on gasoline[1] in use throughout California. These overpressure alarms were particularly troublesome for the GDF operator due to their frequency in winter and expense associated with troubleshooting and repair.

ARB staff initiated a field study in 2008 to better understand the cause of the overpressure alarms and what could be done to mitigate the impact on GDF operators. CARB found that over 90 percent of total overpressure alarms occurring between November and March were not attributed to an equipment failure and took steps to offer short-term relief to GDF operators. To address the short-term problem of these false alarms, CARB worked with the California Air Pollution Control Officers Association (CAPCOA) to draft Advisory 405, which was released in 2009. The advisory, and subsequent amended versions, allowed station operators to clear ISD overpressure alarms between November 1 and March 31. At the time CARB released the advisory, it

---

[1]CARB regulations limit the RVP of gasoline to 7 psi during the summer season, but these limits do not apply from November 1 through March 31.

was understood to be a short-term solution and CARB staff committed to a long-term study and public workshops that would lead to a permanent solution and possible regulatory action in 2013.

After conducting public workshops in October and November 2012, CARB staff were presented with pressure and ullage data from 12 GDFs equipped with Assist EVR systems located in the South Coast Air Quality Management District (SCAQMD). The data from the sites was collected during the winter fuel season and showed that all 12 sites exhibited rising pressure in the underground storage tanks during gasoline dispensing. Under normal operating conditions, the assist EVR system operates below atmospheric pressure or at negative pressure. Negative pressure is desirable because pressure driven fugitive and vent line emissions are nonexistent.

Additionally, each UST system exhibited overpressure for prolonged periods of time. A review of the alarm history was conducted for 8 of the 12 sites (ISD performance standards only require archiving one year of alarm history data and an extended alarm history was not available for 4 sites). The alarm history revealed a significant increase in the number of overpressure alarms for the 2012-2013 winter compared to the previous two winters. As pressure profiles remained unchanged after testing and minor repairs, CARB staff determined that the overpressure occurrences were unlikely to be caused by equipment defects and suspected that the volatility of gasoline being delivered to these sites during the winter months was likely the root cause of the overpressure. Just days after Southern California refineries began distributing summer gasoline, the overpressure occurrences ceased to exist at all 12 sites.

To study the issue further, CARB staff collected data from 46 randomly selected sites in Sacramento and San Diego from January through March, 2013. Staff estimated that 11 percent of the Sacramento sites and 40 percent of San Diego sites exhibited overpressure during dispensing. These numbers led staff to question the percentage of GDFs statewide that could be experiencing overpressure and increased pressure-while-dispensing, or PWD, as well as how the statewide emission estimate would be affected by GDFs that operate at higher than expected pressures. Staff then proposed a larger statewide study, the Mega Blitz, which involved the collection of ISD alarm history and pressure and ullage data stored on the ISD console.

Mega Blitz

The “Mega Blitz of 2013/2014” describes as study undertaken by CARB staff to collect ISD data and GDF operating characteristics from nearly 400 GDFs located in nine defined geographic regions which collectively account for approximately 95 percent of the GDFs in California. The sample number from each region was weighted based on the percentage of the State’s GDFs that are located in that district (see Table II-1). A sample size of 400 GDFs was determined to represent approximately 5 percent sample size of the total number of GDFs with ISD throughout California. A large sample size and widespread spatial distribution of GDFs was necessary to identify the causes and trends associated with overpressure in order to provide an effective solution.

Table II-1: Sample Distribution for Field Study 400 ISD Data Downloads (5% sample size)

Region	South Coast AQMD	Bay Area AQMD	San Joaquin Valley Unified AQMD	Central Coast, North Coast, S.E. Desert, Mountain Co. Regions	San Diego Co. APCD	Sacramento Valley Region	Regions Not Sampled	Total
% of Statewide GDF w/ ISD	40.3%	17.1%	11.3%	11.1%	8.3%	6.9%	4.9%	100%
Target Number of GDF ISD Downloads	136	58	38	37	28	23	0	200
Target Number of Assist ISD Downloads	93	36	25	26	NA*	NA*	0	180
Target Number of Balance ISD Downloads	43	22	13	12	NA*	NA*	0	90
Number of Oversampled GDF ISD Downloads	0	0	0	0	57	23	0	80
Total Downloads Per District or Multi-District Region	136	58	38	37	85	46	0	400

Notes:

23 Sites (6.9%) from Sacramento Region - 3 Districts, 5 counties: Sac Metro AQMD, Yolo-Solano AQMD (Yolo & Solano Counties), Feather River AQMD (Sutter & Yuba counties). Sacramento Region includes 23 sites over sample.

20 Sites (6.3%) from Central Coast Region - 4 Districts, 6 counties: MBARD (Monterey, Santa Cruz and San Benito Counties), Ventura, San Luis Obispo, Santa Barbara APCDs.

7 Sites (2.0%) from South East Desert Region - 2 Districts, 3 counties: Mojave Desert AQMD (Parts of San Bernardino and Riverside Counties), Imperial APCD.

6 Sites (1.7%) from Mountain Co. Region - 7 Districts, 9 Counties: Amador, Calaveras, El Dorado, Mariposa, Placer, and Tuolumne APCDs, and Northern Sierra AQMD (Nevada, Plumas, and Sierra).

4 Sites from (1.1%) North Coast Region - 3 Districts, 5 Counties: North Coast AQMD (Del Norte, Humboldt, Trinity) Mendocino AQMD, and Northern Sonoma APCD.

The sample population for ISD downloads was further subdivided by the type of EVR system installed at each GDF. In 2013, approximately 70 percent of GDFs have a Healy Assist EVR Phase II system installed under Executive Order (EO) VR-202, while 30 percent operate either a VST or EMCO Balance Phase II EVR system under EO VR-204. Similarly, the ISD system type is split between two different manufacturers, Veeder-Root and INCON. Approximately 90 percent of ISD systems are Veeder-Root, while 10 percent are INCON. Based on this information, it was determined that data gathering activities during the Mega Blitz would attempt to emulate the distribution of EVR and ISD system type weighted by manufacturer sales. (Table 1, Appendix I)

Once the sites were selected, staff proposed data collection from each site to occur in a two to three week period before the RVP limit changes on November 1 and March 31 and a two to three week period after the RVP change. These collections dates would ensure the capture of pressure data before and after the wintertime switch to high RVP fuel and the pressure data before and after the summertime switch to control RVP fuel, in October, December, February, and April. The data downloads were performed primarily by CARB staff with site access provided by local air district staff. In some cases, especially in the South Coast AQMD, district staff performed the data download.

To conduct each site visit, both CARB and district staff were sent out with detailed ISD download instructions, a list of ISD download commands, an informational letter for the GDF operators, cables, laptop computers, and a data form for GDF details and operating parameters. The ISD download instructions (see Appendix II) detailed the explicit steps to take while connecting to the ISD console (Veeder-Root) via laptop and inputting the ISD text commands that indicate what report data to copy and save. The specific download commands include:

- Vapor Pressure Events (see Figure II-1 below);
- ISD Monthly Status Report (see Figure II-2 below);
- ISD Daily Report (see Figure II-3 below);
- Delivery Report (see Figure II-4 below);
- Flowmeter, AFM Busy Events Report (see Figure II-5 below); and
- Assist Vapor Collection Test Results / Balance Flow Monitoring Test Results (see Figure II-6 below).

The informational letter provided to GDF operators (see Appendix III) explained the purpose of the staff visit and download and provided staff contact information for those with questions or concerns. The GDF data collection form (see Appendix IV) prompted staff to document detailed information on the EVR and ISD systems, inventory reports, fuel deliveries, and site information. In order to properly examine the Mega Blitz information, all ISD overpressure and leak alarm data, as well as GDF site characteristics were consolidated into an Excel database.

Figure II-1: Example of Raw ISD Data – Vapor Pressure Events Command

```
OCT  8, 2013 10:32 AM
VAPOR PRESSURE EVENTS
INDEX  DATE-TIME                PRESSURE ULLAGE   FLAGS
0001   13-10-07 04:22:52          -0.013  25880.1  0000
0002   13-10-07 04:23:12          -0.014  25880.1  0000
0003   13-10-07 04:23:32          -0.016  25880.1  0000
0004   13-10-07 04:23:53          -0.017  25880.1  0000
0005   13-10-07 04:24:13          -0.018  25880.1  0000
0006   13-10-07 04:24:33          -0.019  25880.1  0000
0007   13-10-07 04:24:53          -0.019  25880.1  0000
0008   13-10-07 04:25:13          -0.020  25880.1  0000
0009   13-10-07 04:25:33          -0.020  25880.1  0000
0010   13-10-07 04:25:53          -0.020  25880.2  0000
```

Figure II-2: Example of Raw ISD Data – Via ISD Monthly Status Report Command

```
OCT  8, 2013 10:39 AM

ISD MONTHLY STATUS REPORT

EVR TYPE: BALANCE
ISD TYPE: 01.04
VAPOR PROCESSOR TYPE: VEEDER-ROOT POLISHER

OVERALL STATUS           :WARN        EVR VAPOR COLLECTION :WARN
EVR VAPOR CONTAINMENT    :WARN
ISD MONITOR UP-TIME      :100%
EVR/ISD PASS TIME        : 62%        VAPOR PROCESSOR      :PASS


ISD MONITORING TEST PASS/FAIL THRESHOLDS
                                                  PERIOD   BELOW  ABOVE

VAPOR COLLECTION BALANCE SYS FLOW PERFORMANCE      1DAYS    0.60  ----
VAPOR CONTAINMENT GROSS FAIL, 95th PERCENTILE      7DAYS    ----  1.30"wcg
VAPOR CONTAINMENT DEGRADATION, 75th PERCENTILE    30DAYS    ----  0.30"wcg
VAPOR CONTAINMENT LEAK DETECTION FAIL @2"WCG       7DAYS    ----  12.50cfh
STAGE I VAPOR TRANSFER FAIL, 50th PERCENTILE      20MINS    ----  2.50"wcg
VAPOR PROCESSOR SELF TEST FAIL                     1DAYS    ----  ----
VAPOR PROCESSOR MASS EMISSION FAIL (LB/KGAL)       1DAYS    ----  0.32

WARNING ALARMS
DATE     TIME     DESCRIPTION                     READING         VALUE
13-10-03 10:00:40 VAPOR CONTAINMENT LEAKAGE       CFH@2 INCHES WC  78.73
13-10-02 10:00:50 VAPOR CONTAINMENT LEAKAGE       GROSS FAIL
13-10-01 10:01:52 FLOW PERFORMANCE HOSE BLOCKAGE  FP 8 BLEND3       0.59
FAILURE ALARMS
DATE     TIME     DESCRIPTION                     READING         VALUE

SHUTDOWN & MISCELLANEOUS EVENTS
DATE     TIME     DESCRIPTION                     ACTION/NAME
13-10-04 08:42:10 CONTAINMENT VAPOR LEAKAGE      TEST MANUALLY CLEARED
13-10-01 12:17:50 COLLECTION TEST HH08 GRADE      TEST MANUALLY CLEARED
```

Figure II-3: Example of Raw Data - Via ISD Daily Report Command

```
ISD DAILY REPORT DETAILS

EVR TYPE: BALANCE
ISD TYPE: 01.02
VAPOR PROCESSOR TYPE: VEEDER-ROOT POLISHER
|
OVERALL STATUS            :WARN          EVR VAPOR COLLECTION :PASS
EVR VAPOR CONTAINMENT     :WARN
ISD MONITOR UP-TIME       :100%          STAGE I TRANSFERS:  1 of  1 PASS
EVR/ISD PASS TIME         : 90%          VAPOR PROCESSOR      :WARN

Status Codes: (W)Warn (F)Fail (D)Degradation Fail (G)Gross Fail
(ISD-W)ISD Self-Test Warning (ISD-F)ISD Self-Test Fail (N)No Test

       ISD    ISD   ---CONTAINMENT TESTS---     STAGE        ---COLLECTION TESTS
       EVR    %UP   GROSS  DGRD  MAX  MIN  LEAK   I    VAPOR  FP1   FP2   FP3
DATE  STATUS TIME   95%    75%  "WC  "WC   CFH  XFR   PRCSR  BLEND BLEND BLEND
03/01   PASS 100%  0.5   -0.0   0.0 -1.1    0         PASS   0.94  0.81  0.95
03/02   PASS 100%  0.4    0.0   0.2 -1.0    0         PASS   0.86  1.02  0.94
03/03   PASS 100%  0.5    0.0   0.8 -2.0    6         PASS   0.90  1.11  0.95
03/04   PASS 100%  0.4    0.0   2.0 -1.1    7         PASS   0.96  0.97  0.93
03/05   PASS 100%  0.4    0.0   0.0 -1.0    7         PASS   0.82  0.80  0.79
```

Figure II-4: Example of Raw ISD Data - Via Delivery Report

```
OCT  8, 2013 10:47 AM

DELIVERY REPORT

T 1:UNLEADED 87
INCREASE   DATE / TIME               GALLONS TC GALLONS WATER  TEMP DEG F  HEIGHT

      END: OCT  7, 2013 11:42 AM        6873       6767  0.00       81.99   53.44
    START: OCT  7, 2013 11:20 AM        2332       2286  0.00       87.74   24.32
   AMOUNT:                              4541       4481

      END: OCT  3, 2013  1:28 PM        7579       7481  0.00       78.44   57.67
    START: OCT  3, 2013  1:04 PM        1645       1620  0.82       81.04   19.07
   AMOUNT:                              5934       5861

      END: SEP 30, 2013  9:10 AM        7002       6921  0.00       76.45   54.21
    START: SEP 30, 2013  8:46 AM        1104       1086  0.00       83.30   14.49
   AMOUNT:                              5898       5835

      END: SEP 25, 2013  6:00 PM        7160       7058  0.00       80.28   55.16
    START: SEP 25, 2013  5:34 PM        1213       1190  0.00       86.03   15.45
   AMOUNT:                              5947       5868

      END: SEP 23, 2013 12:41 PM        4726       4650  0.00       82.83   40.33
    START: SEP 23, 2013 12:23 PM         490        480  0.00       88.68    8.34
   AMOUNT:                              4236       4170

      END: SEP 18, 2013  5:51 PM        6721       6623  0.00       80.78   52.52
    START: SEP 18, 2013  5:24 PM         898        881  0.79       86.58   12.58
   AMOUNT:                              5823       5742

      END: SEP 15, 2013 10:16 AM        6071       5982  0.00       80.84   48.60
    START: SEP 15, 2013  9:57 AM        1521       1496  0.00       83.37   18.06
   AMOUNT:                              4550       4486

      END: SEP 11, 2013  6:35 PM        6331       6239  0.00       80.57   50.17
    START: SEP 11, 2013  6:09 PM         538        529  0.00       84.29    8.88
   AMOUNT:                              5793       5710

      END: SEP  7, 2013  6:33 AM        6152       6054  0.00       82.56   49.09
    START: SEP  7, 2013  6:08 AM        1626       1596  0.00       85.46   18.91
   AMOUNT:                              4526       4458

      END: SEP  3, 2013  5:55 PM        6861       6742  0.00       84.54   53.36
    START: SEP  3, 2013  5:24 PM         965        947  0.00       85.24   13.21
   AMOUNT:                              5896       5795
```

Figure II-5: Example of Raw ISD Data – Via Flowmeter, AFM Busy Events Command

```
OCT  8, 2013 10:47 AM
AFM BUSY EVENTS: FLOWMETER 1
INDEX START DATE-TIME     DUR    A/L     VAPOR   FUEL  #EV FLAGS  FPS    HOSES
 0001 13-09-08 13:10:50    76    0.23      3.2   14.0    1  003E  02     01
 0002 13-09-08 13:44:17    59    0.33      1.7    5.2    1  003E  02     01
 0003 13-09-08 15:17:59    39   -0.03     -0.3    9.3    1  003E  02     01
 0004 13-09-08 15:38:20   164   -0.20     -2.9   14.9    1  003E  01     00
 0005 13-09-08 16:11:38   108    0.20      3.2   15.9    1  003E  02     01
 0006 13-09-08 16:50:12   233    1.94     25.1   12.9    1  003E  02     01
 0007 13-09-08 17:37:59   170    0.62      9.7   15.6    1  002E  01     00
 0008 13-09-08 19:14:56    65    1.35     12.2    9.0    1  002E  02     01
 0009 13-09-08 20:25:43    87    0.69      6.9   10.0    1  002E  02     01
 0010 13-09-08 21:02:16   117    0.26      2.8   10.6    1  003E  02     01
 0011 13-09-08 21:30:51    81    0.08      0.4    5.0    1  003E  02     01
 0012 13-09-08 21:42:27    59    0.82      3.9    4.7    1  002E  02     01
 0013 13-09-08 22:01:58    66    0.08      0.4    5.3    1  003E  02     01
 0014 13-09-09 06:57:05    31    0.67      1.4    2.1    1  0037  02     01
 0015 13-09-09 07:01:23   135    0.32      2.1    6.3    1  003E  01     00
 0016 13-09-09 08:09:11    26    1.72      1.7    1.0    1  0037  02     01
```

Figure II-6: Example of Raw ISD Data - Via Vapor Collection Test Results / Balance Flow Monitoring Command

```
OCT  8, 2013 10:58 AM
BALANCE FLOW MONITORING TEST RESULTS


Rec# Test_Timestamp     EstPrOrvr OrvrLimit SiteChi^2 CritVal SiteChi^2Result
0330 13-09-02 09:59:09  78.52%    94.00%    143.16     20.48  valid_orvr_tests
Dispenser---- -----Flow Monitoring--- ---------------Orvr--------------
Labl Hose AFM  Status  A/L   Days Evnt Status  V  #0 #AL %Blck %Thrs %Zero
  01  00  00   PASS    0.87 11.8   68 PASS     0  30  68 44.12 92.50 64.54
  02  00  00   PASS    0.92  3.9   91 PASS     0  31  91 34.07 90.60 66.44
  03  00  01   PASS    0.98  4.9   69 PASS     0  57  69 82.61 92.40 64.64
  04  00  01   PASS    0.98 10.9   69 PASS     0  60  69 86.96 92.40 64.64
  05  00  02   PASS    0.84  0.8   70 PASS     0  52  70 74.29 92.30 64.74
  06  00  02   PASS    0.70  3.9   72 PASS     0  48  72 66.67 92.11 64.93
  07  00  03   PASS    0.83  3.9   77 PASS     0  64  77 83.12 91.66 65.38
  08  00  03   NOTEST     N  0.6    2 PASS     0   2   2100.00  0.00  1.00
  09  00  04   PASS    0.88  8.9   73 PASS     0  68  73 93.15 92.01 65.03
  10  00  04   PASS    0.85  8.9   72 PASS     0  59  72 81.94 92.11 64.93
  11  00  05   PASS    0.90  3.9   82 PASS     0  67  82 81.71 91.25 65.79
  12  00  05   PASS    0.92  3.9   72 PASS     0  62  72 86.11 92.11 64.93
```

III: Methodology

Once CARB and district staff conducted their site visits and collected the target data, CARB staff returned to the office and created two large Excel databases, one for overpressure alarms and the other for leak alarms, in which to assemble and analyze the information. The goal was to determine whether a correlation existed between GDF operating parameters and overpressure occurrence severity. Additionally, an Excel macro program was created that pulls a segment of the ISD download (the ullage pressure and volume) to flag and identify sites that exhibit PWD, called “VR Vapor Pressure Events P/U Plot.” A second Excel macro was created that pulls a different segment of the ISD download, the most recent 1,000 refueling transaction data available for each dispenser to determine site vapor-to-liquid (V/L) ratio and overall distribution of V/L, called “Histogram Assistance Tool” (HAT).

Mega Blitz Database – Overpressure Alarms

For the two Excel databases created, each was initially populated with 46 fields for each GDF site. The data for each GDF site includes information on location, hours of operation, types of vapor recovery and ISD systems, recent fuel deliveries, gasoline throughput, gasoline capacity, average UST and delivered fuel temperatures at each site visit, and changes to the sites between visits. Once specific site details were recorded, staff then populated another 32 fields with overpressure warning alarm information. For the Overpressure Alarm specific database (see Appendix V), staff analyzed the ISD downloads going as far back as October 2011. From the ISD monthly reports, staff tabulated the overpressure warning alarm occurrences in each month, up until the last Mega Blitz download site visit in April 2014.

Mega Blitz Database – Leak Alarms

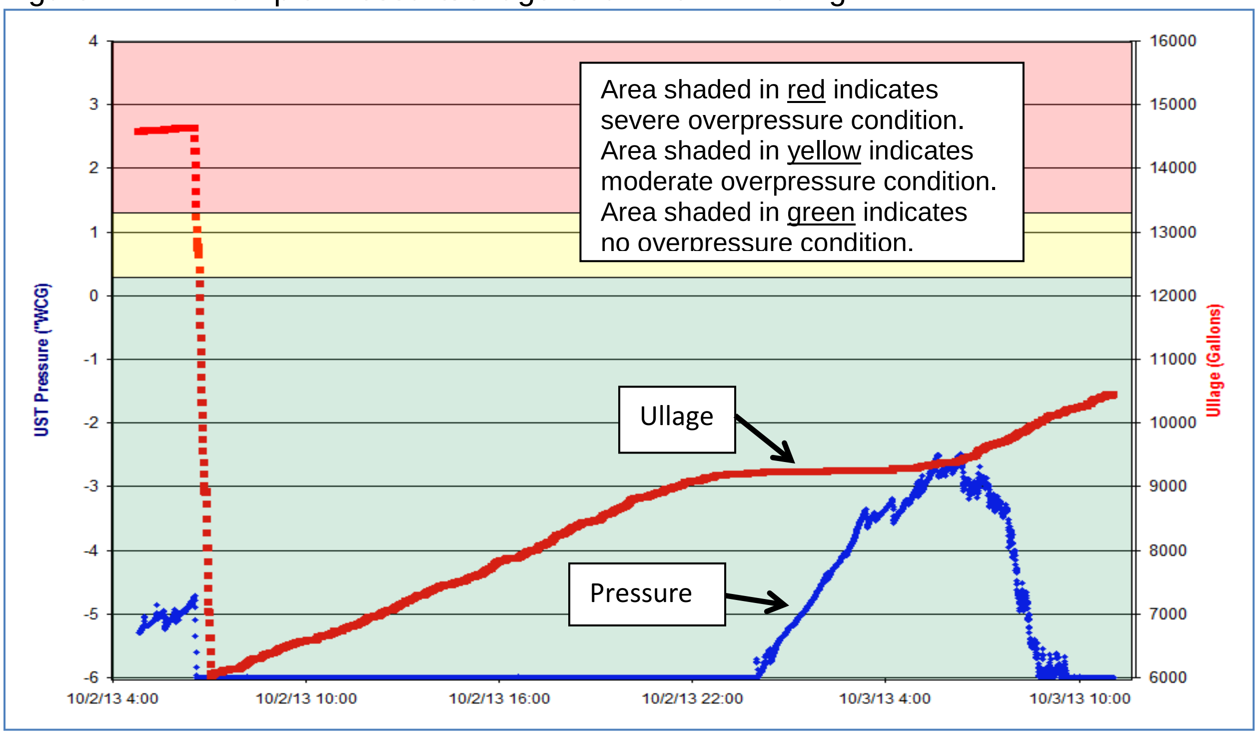
The Mega Blitz Leak Alarm database (see Appendix VI) consisted of the same 46 GDF site specific fields as the Mega Blitz Overpressure Alarm database. However, instead of quantifying the overpressure warning alarms taking place each month and across the entire Mega Blitz study period, it quantifies the warning leak alarms occurring monthly. With data gleaned from the ISD alarm reports, staff populated 32 fields with monthly leak alarm totals from October 2011 to April 2014, and tabulated the alarm totals and frequency for each site.

VR Vapor Pressure Events P/U Plot – PWD Identification

Along with quantifying frequency of overpressure and leak alarms pulled from the ISD data downloads, staff also examined the UST pressure data contained in ISD Vapor Pressure Events command for evidence of PWD. The Vapor Pressure Events command provides the most recent 30 hours of pressure and ullage data and consists of 5,400 records. To identify PWD, staff created an Excel macro, VR Vapor Pressure Events P/U Plot, that identified which sites demonstrated specific data traits (flags). The PWD flags included identifying sites where: at least 20 percent of the daily ullage pressure data must exceed 1.3 “WC; at least 75 percent of the daily ullage pressure data are less than 0.2 “WC and greater than -0.2 “WC, deemed invalid data (flat-lined, indicative of a leak); and at least three consecutive hours of positive pressure slope and positive ullage volume based on daily ullage pressure data. Once the raw ISD data file was fed into the macro and the queried flags identified, staff were able to identify specific GDF sites exhibiting instances of PWD in each of the four rounds of data downloads. See Appendix VII for an example of the VR Vapor Pressure Events P/U Plot macro.

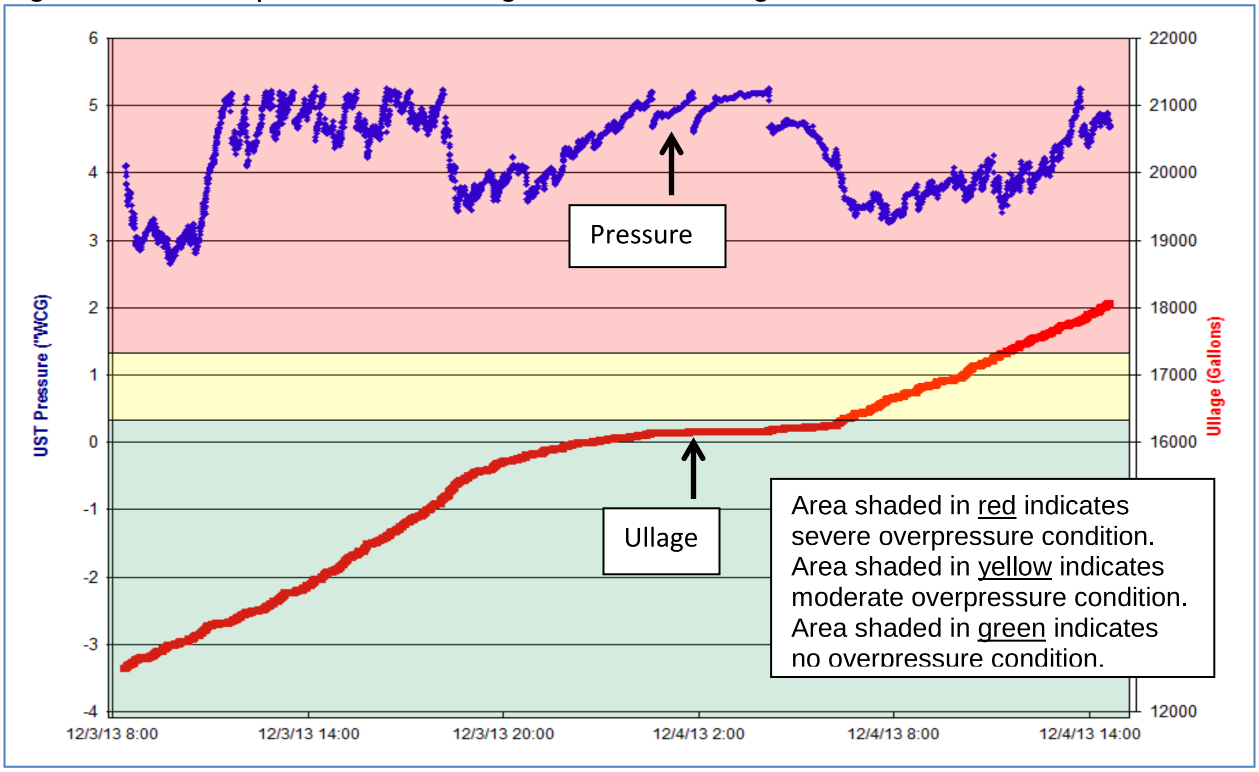
Using the VR Vapor Pressure Events P/U Plot tool, staff generated pressure and ullage charts for each GDF as depicted in Figure III-1 below, demonstrating a typical site where PWD is not exhibited. In the example below, as ullage increases (more gasoline dispensed), UST ullage pressure stays in vacuum, increasing overnight when use is low, but not reaching positive pressure.

Figure III-17: Example Pressure/Ullage Chart Not Exhibiting PWD



Using the VR Vapor Pressure Events P/U Plot tool, staff generated Figure III-2 below, which demonstrates and/or provides an example of a site that is exhibiting PWD. While gasoline is dispensed and ullage increases over approximately a day and a half, the UST ullage remains in positive pressure.

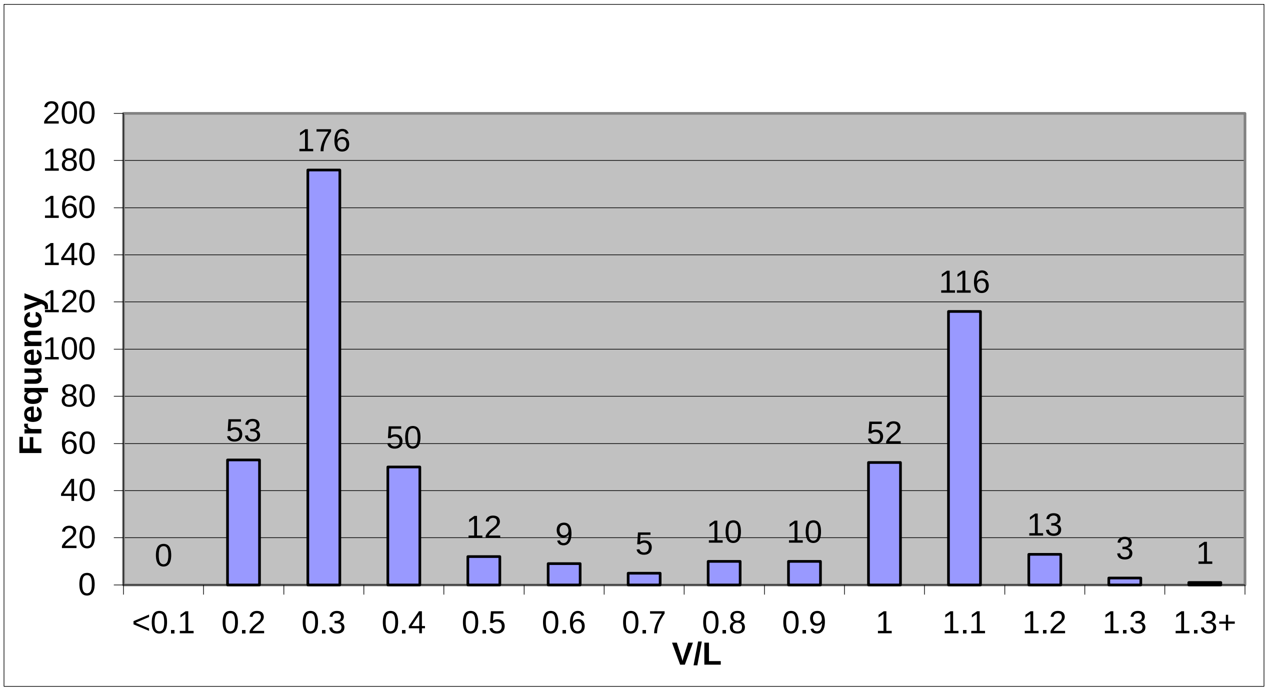
Figure III-2: Example Pressure/Ullage Chart Exhibiting PWD



Histogram Assistant Tool (HAT) – Distribution of V/L and Site Average V/L

In addition to the VR Vapor Pressure Events P/U Plot macro, CARB staff created an Excel macro called the Histogram Assistant Tool (HAT) (see Appendix VIII). The HAT queried individual GDF site ISD data for the vapor-to-liquid ratios (V/L) of specific fueling points and hoses at each location, providing the distribution of V/L for the most recent 1,000 individual fueling transaction for each vapor flow meter, and the V/L average for the entire site. The HAT tool allows staff to determine whether the distribution of V/L falls within a normal pattern for each GDF location. An example of a normal distribution is depicted in Figure III-3 below. Notice the large number of fueling transactions with a V/L of 0.3 which is indicative of assist nozzle performance with ORVR vehicles and the large number of fueling transactions with a V/L of 1.1 which is indicative of assist nozzle performance with non-ORVR vehicles. The HAT also allowed staff to determine the site average vapor to liquid ratio (all fueling events are included) of the various classifications of GDF including assist with PWD, assist with no PWD, and balance systems.

Figure III-3: Example V/L Distribution Generated from HAT Macro



Data Entry QA/QC

In order to properly assess and draw conclusions from the data gathered and analyzed during the Mega Blitz of 2013/2014, it was necessary to perform quality assurance/quality control (QA/QC) on the databases created by staff. As data was manually entered into the Mega Blitz databases, staff performed data entry checks on one another's entries to ensure accuracy. If discrepancies were discovered, staff made the corrections in the main databases while keeping track of errors and corrections made in separate Excel tables (see Appendix IX). While staff checked the accuracy of specific GDF site information, the main focus of the QA/QC was on the overpressure and leak alarm counts. Staff performing the data checks corrected multiple overpressure and leak alarm counts for GDF sites in each region across the state ensuring the accuracy of data that is instrumental in determining the causes and solutions for overpressure occurrences.

IV: Results

Once data gathering, development of a database, review, QA/QC, and analysis was completed for the Mega Blitz of 2013/2014, staff could begin to generate results that were shared with staff from the local air districts as well as manufacturers and members of the public. All results from the study were shared with the CAPCOA Vapor Recovery Subcommittee via a series of emails and meetings beginning in April 2014, going through August 2014. In addition, public workshops were held in March 2014 and November 2015.

General Information

During the data analysis phase of the Mega Blitz of 2013/2014, staff generated multiple tables of basic information to identify trends, correlations, frequency, and root causes of the overpressure phenomenon. Before the data could be fully analyzed, staff needed to determine what parameters to examine. Key GDF operating characteristics were identified and the individual GDF site data forms were developed to narrow down the desired information. Table IV-1 lists parameters which can affect UST pressure profiles and how they can vary based on facility, geographic region, and temporal factors (hourly, daily, seasonally, or yearly). In attempting to determine the causes of overpressure and PWD, staff analyzed all the collected data in comparison to many of the following parameters.

Table IV-1: Parameters Which Can Affect the UST Pressure Profile

Parameters	**Variation by Facility**	**Variation by Geographic Region**	**Temporal Variation**
GDF Throughput	Yes	No	Daily
GDF Ullage Volume	Yes	No	Daily
GDF Operating Schedule (length of time dispensers are idle)	Yes	No	No
GDF ORVR Vehicle Throughput	Yes	Yes	No
RVP of Stored Gasoline	No	Northern vs. Southern Refineries	Seasonal
Temperature of Stored Gasoline	Slight	Yes	Seasonal
Phase I Delivery Operations	Yes	No	No
RVP of Fuels Delivered from Cargo Tanks	No	Slight	Seasonal
Temperature of Gasoline from Cargo Tanks	No	Yes	Seasonal
Phase II Nozzle Design	Yes	No	No
In-Use Fueling Point V/L Ratios	Yes	No	No
Vehicle Tank Temperatures	Yes	Yes	Seasonal
Vehicle Fill Pipe Designs	Regional	Regional	Years
Vapor Containment Space Pressure Integrity	Yes	No	No
VRS Pressure Management System Design and In-Use Performance	Yes	No	No
VRS PV Valve Design and In-Use Performance	Yes	No	No
Leaks in Secondary Containment Interstitial Spaces for Systems Installed 2004 and After	Yes	No	No
Leaks in Liquid Siphon Lines Used to Balance Fuel levels in Tanks Connected to Siphon Manifold	Yes	No	No
Barometric Pressure Changes	Yes	Yes	Hourly
Solar Heating of Aboveground Components Affixed to the UST	Yes	Yes	Hourly

Table IV-2 provides information on the number and type of GDFs studied. The table differentiates between assist and balance EVR systems, hours of operation, and winter versus summertime overpressure alarm occurrences. The data presented was gathered from the first two rounds of ISD data downloads in October and December

2013 and pulled from stored alarm information dating back to April 2012. There were a total of 395 GDF sites initially studied in the Mega Blitz, with 272 being assist EVR system sites and 123 being balance EVR system sites. 313 of those sites were open 24 hours a day and 82 shut down service at night. Overpressure alarm occurrences were high in the wintertime fuel months, with 2,329 alarms taking place between December 2012 and March 2013, and in November 2013. Overpressure alarms in the summertime fuel months between April 2012 and October 2013, were relatively low, totaling 317.

Table IV-2: General Site Information – Statewide

All Sites	Number	Percent
Sites in Mega Blitz	395	N/A
Assist Sites in Mega Blitz	272	68.9%
Balance Sites in Mega Blitz	123	31.1%
Sites open 24 Hours	313	79.2%
Sites that shutdown at night	82	20.8%
OP Alarms: Dec 2012 – March 2013 & Nov 2013 (Winter)	2329	N/A
OP Alarms: April 2012 – October 2013 (Summer)	317	N/A
Ratio of Winter vs Summer OP Alarms	7.3	N/A
Sites with Veeder-Root ISD	377	95%
Sites with INCON ISD	18	5%

Tables IV-3 and IV-4 lists the factors associated with overpressure alarm occurrences for all sites in October and November 2013, respectively. Staff looked at the number and percentage of overpressure alarms in comparison to hours of operation (24 hour sites versus those that shut down at night). There was a ten-fold increase in the total number of overpressure alarms from October to November (the switch to winter fuel) and more sites experienced at least one overpressure alarm in November as compared to October. In October 2013, there was on average 0.12 overpressure alarms per GDF, with an average of 0.11 overpressure alarms at 24 hour sites and 0.13 overpressure alarms at sites that shut down at night. In November 2013, there was on average 1.39 overpressure alarms per GDF, with an average of 1.38 overpressure alarms at 24 hour sites and 1.43 overpressure alarms at sites that shut down at night.

Table IV-3: General Site Information for October 2013

October 2013 - All Sites	Number	Percent
Sites with at least 1 OP Alarm in Oct 2013	26	6.6%
Total number of OP Alarms in October 2013	46	N/A
OP Alarms/GDF	0.12	N/A
OP Alarms at 24 Hour sites in Oct 2013	35	76.1%
OP Alarms/GDF at 24 Hour sites in Oct 2013	0.11	N/A
OP Alarms at sites that shut down at night in Oct 2013	11	23.9%
OP Alarms/GDF that shut down at night in Oct 2013	0.13	N/A

Table IV-4: General Site Information for November 2013

November 2013 - All Sites	Number	Percent
Sites with at least 1 OP Alarm in Nov 2013	215	54.4%
Total number of OP Alarms in Nov 2013	548	N/A
OP Alarms/GDF	1.39	N/A
OP Alarms at 24 Hour sites in Nov 2013	431	78.6%
OP Alarms/GDF at 24 Hour sites in Nov 2013	1.38	N/A
OP Alarms at sites that shut down at night in Nov 2013	117	21.4%
OP Alarms/GDF that shut down at night in Nov 2013	1.43	N/A

Preliminary Findings – Overpressure and Leak Alarms

Initial findings from the Mega Blitz study and data analysis focused on the site visits from October and November 2013. Table IV-5 below shows the prevalence of overpressure alarms from that time period, as all GDF sites combined and then the split between assist and balance EVR system sites. There was an average of 0.12 overpressure alarms per site in October 2013 with summertime fuel, which increased to an average of 1.39 overpressure alarms per site in November 2013 with wintertime fuel. From October to November, the percentage of sites with at least one alarm increased from 6.6 percent to 54.4 percent. Alarms per site during that time increased for both assist and balance sites. In November 2013, nearly 70 percent of assist EVR system sites had at least one overpressure alarm while nearly 20 percent of balance EVR system sites experienced at least one alarm.

Table IV-5: Prevalence of Overpressure Alarms

Data Set	Overpressure Alarms	October 2013	November 2013
All Sites Combined (395)	Average Number of Alarms Per Site	0.12	1.39
	% of Sites With at Least One Alarm	6.6%	54.4%
Assist Sites (274)	Average Number of Alarms Per Site	0.16	1.84
	% of Sites With at Least One Alarm	8.8%	69.7%
Balance Sites (121)	Average Number of Alarms Per Site	0.02	0.36
	% of Sites With at Least One Alarm	1.7%	19.8%

Table IV-6 compares the prevalence of leak alarms for the same time periods. There was an average of 0.33 leak alarms per site in October 2013 with summertime fuel, which decreased to an average of 0.29 leak alarms per site in November 2013 with wintertime fuel. From October to November the percentage of sites with at least one alarm stayed the same at 16.2 percent. Alarms per site during that time decreased slightly for assist sites and increased slightly for balance sites. In November 2013, 8.8 percent of assist EVR system sites had at least one leak alarm while 33.1 percent of balance EVR system sites experienced at least one alarm.

Table IV-6: Prevalence of Leak Alarms

Data Set	Leak Alarms	October 2013	November 2013
All Sites Combined (395)	Average Number of Alarms Per Site	0.33	0.29
	% of Sites With at Least One Alarm	16.2%	16.2%
Assist Sites (274)	Average Number of Alarms Per Site	0.19	0.13
	% of Sites With at Least One Alarm	11.7%	8.8%
Balance Sites (121)	Average Number of Alarms Per Site	0.65	0.65
	% of Sites With at Least One Alarm	26.4%	33.1%

Figures IV-1 and IV-2 provide temporal trends of the prevalence of overpressure and leak alarms from month to month. Figure IV-1 displays the number of overpressure alarms occurring monthly, from October 2011 to March 2014, showing the increase in alarms during winter months. Figure IV-2 displays the number of leak alarms occurring monthly, from October 2011, to March 2014, showing an increase in the summer months.

Figure IV-1: Prevalence of Overpressure Alarms, October 2011 to March 2014 (395 Sites)

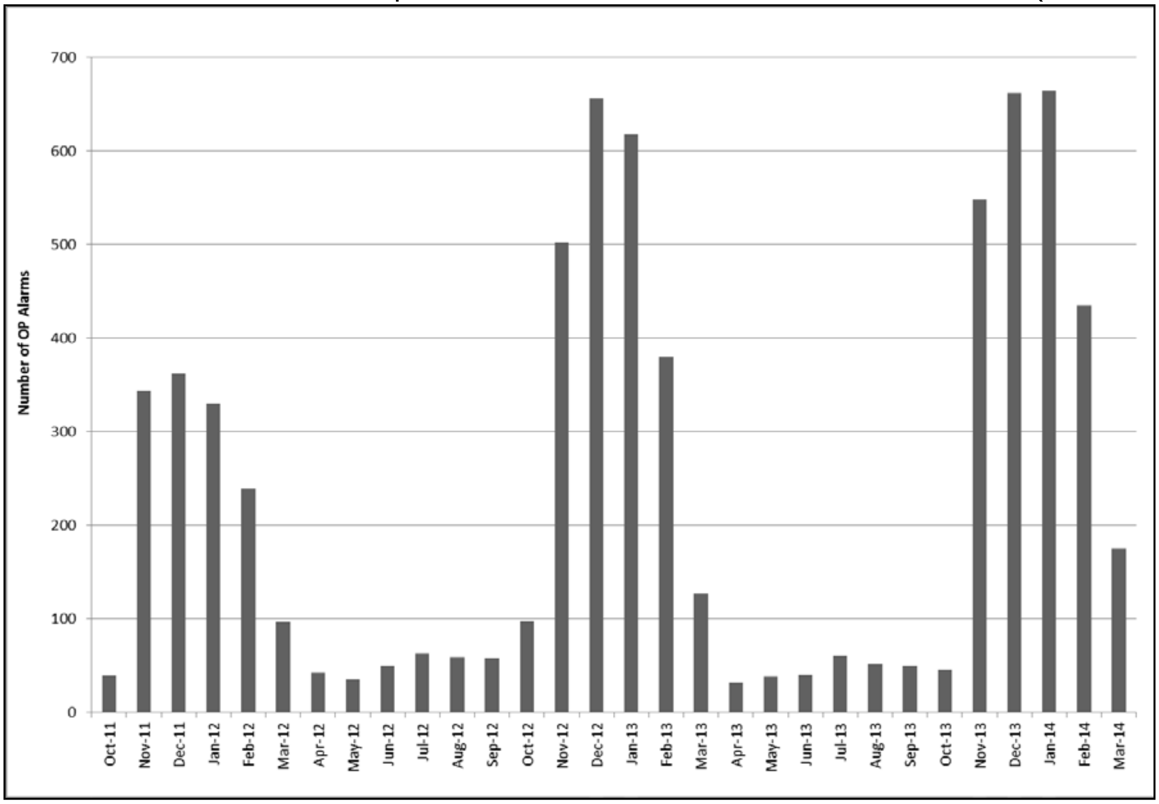
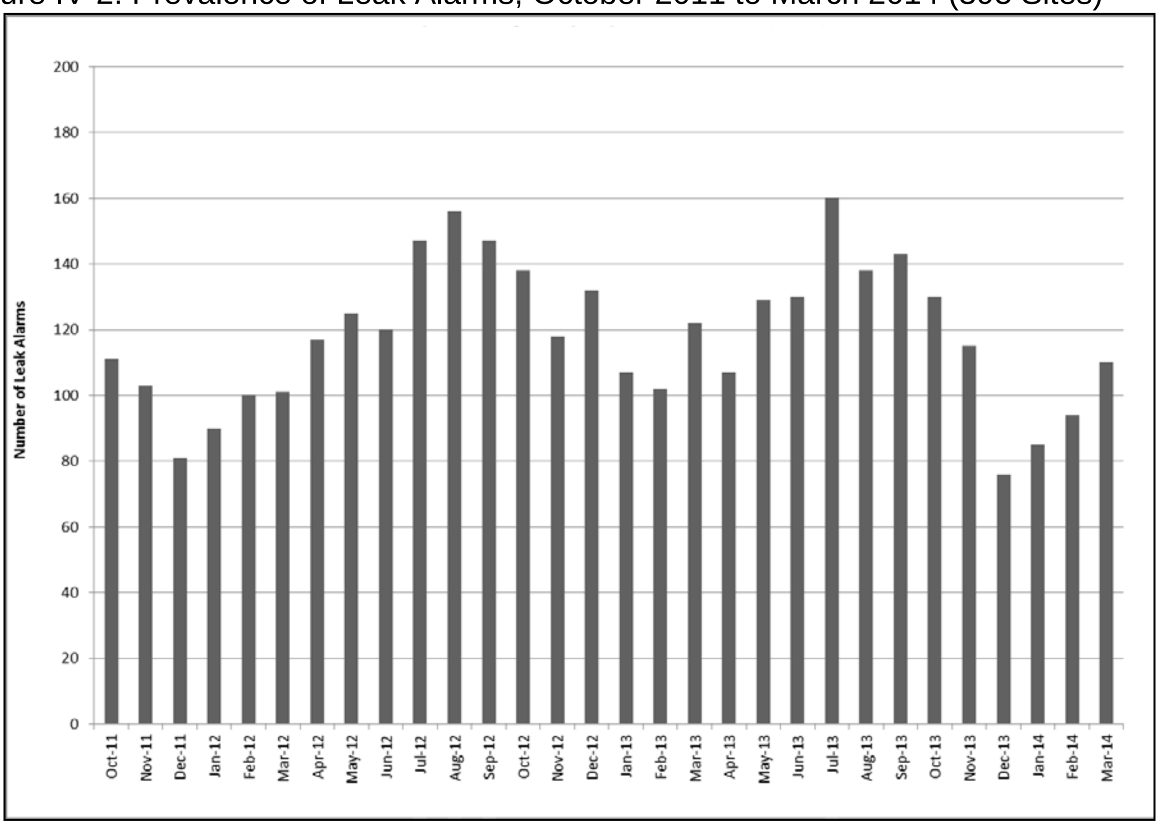


Figure IV-2: Prevalence of Leak Alarms, October 2011 to March 2014 (395 Sites)



PWD Related Findings

The following tables provide information pertaining to the characteristics of GDF sites (assist versus balance, throughput, and hours of operation) in comparison to occurrences of overpressure alarms and PWD within the Mega Blitz study. Table IV-7 displays the percentage of PWD occurrences statewide and regionally from December 2013 to February 2014. Across all regions, instances of PWD at assist EVR system sites decreased from December 2013 to February 2014, falling from 34.2 percent to 24.4 percent. This trend followed in four of the five regions, except for South Coast where PWD occurrence increased from 33.3 percent of assist EVR system sites to 40.2 percent in the same time period. The drops in PWD can likely be attributed to cooler ambient temperatures and lower RVP.

Table IV-7: Statewide PWD Percentage

Location	Assist* PWD – December 2013	Assist* PWD – February 2014
All Counties/Districts	34.2%	24.4%
SJVAPCD	68%	20%
BAAQMD	50%	18%
Sacramento	11.1%	2.8%
San Diego	22.7%	22.7%
South Coast	33.3%	40.2%

*PWD was not observed at balance EVR system sites.

In the examination of general site data, staff reviewed the bill of ladings (BOL) collected at GDFs to identify from which loading terminals GDF sites were obtaining gasoline deliveries to see if sources of gasoline might account for regional differences in PWD. Staff specifically looked at BOLs for December 2013, including which loading terminal provided gasoline deliveries, and whether or not the GDF was experiencing PWD. Table IV-8 below presents that information. With the exception of the Shell and Tesoro loading terminals in the Bay Area, instances of PWD do not appear to be attributed to any specific loading terminal. The percent of GDF sites with PWD are higher for the Bay Area Shell and Tesoro, but the total number of GDF sites is lower for both terminals.

Table IV-8: PWD and Loading Terminals

Region	Loading Terminal	Number of PWD Sites	Number of Non-PWD Sites	Percent of GDF Sites with PWD
Bay Area AQMD (24 BOLs)	Chevron	5	3	62%
	Kinder Morgan	3	6	33%
	Shell	5	1	83%
	Tesoro	1	0	100%
South Coast AQMD (70 BOLs)	Chevron	5	10	33%
	Kinder Morgan	2	7	22%
	Exxon	4	5	44%
	Shell	3	6	33%
	Tesoro	10	18	35%

The general site data collected during the Mega Blitz also provided information such as UST capacity and fuel temperatures. Figures IV-3 and IV-4 examine whether a relationship exists between GDF site UST capacity and frequency of PWD. The majority of sites, PWD and non-PWD, 71 percent and 55.9 percent respectively, have USTs with a capacity between 20 and 35 thousand gallons.

Figure IV-3: UST Capacity and PWD Sites

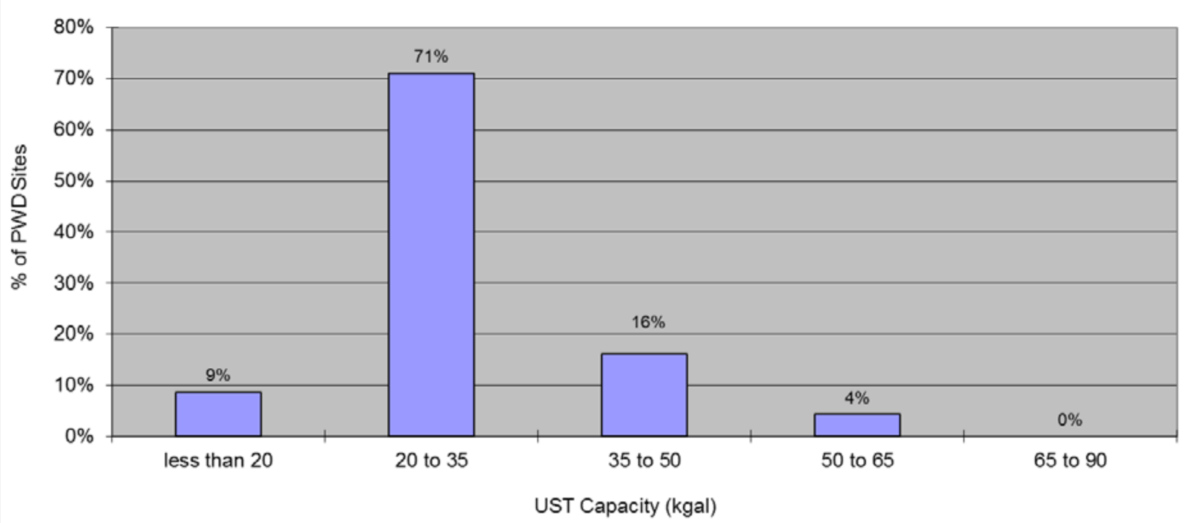
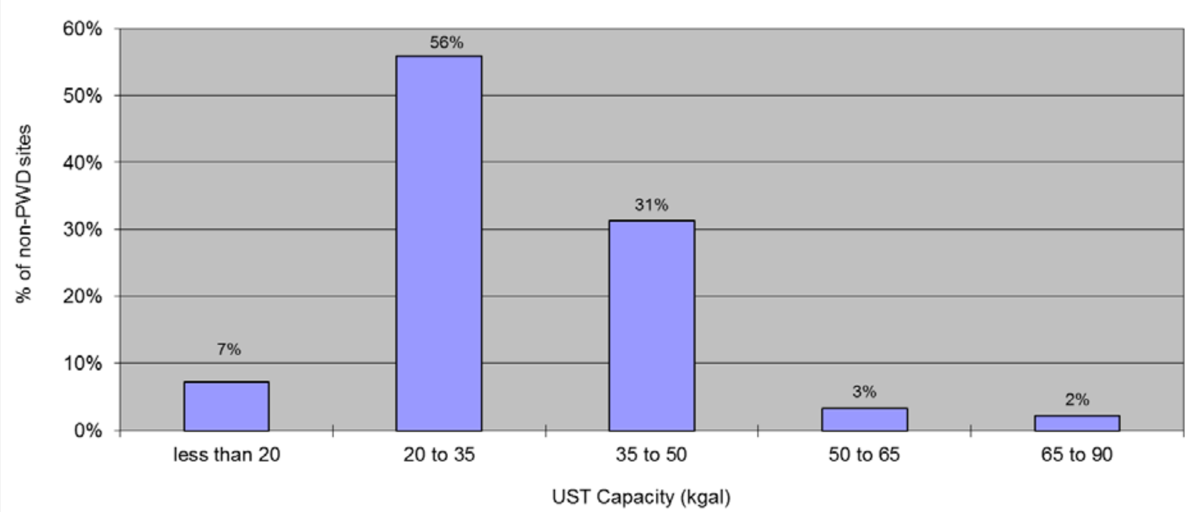
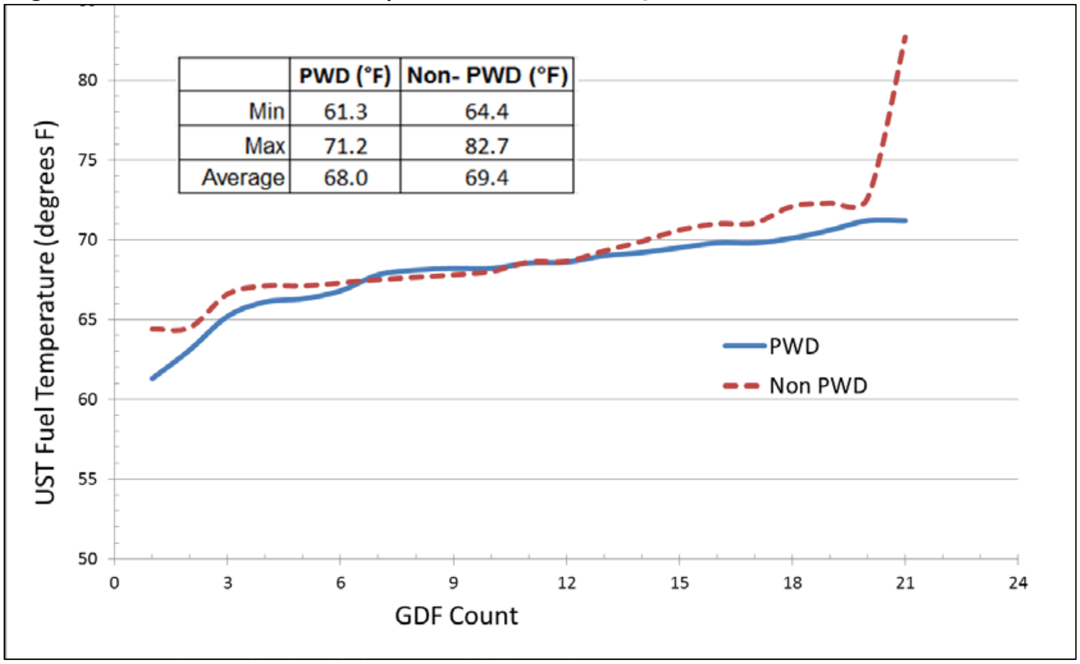


Figure IV-4: UST Capacity and Non-PWD Sites



Figures IV-5 and IV-6 depict staff's examination into the possible effect of fuel temperature on the occurrence of PWD. From the data obtained in the second phase of the Mega Blitz, in December 2013, staff examined PWD and non-PWD sites in South Coast and the Bay Area and looked at the average temperature of the gasoline in their USTs. Average fuel temperatures in both regions and at both PWD and non-PWD sites were relatively similar.

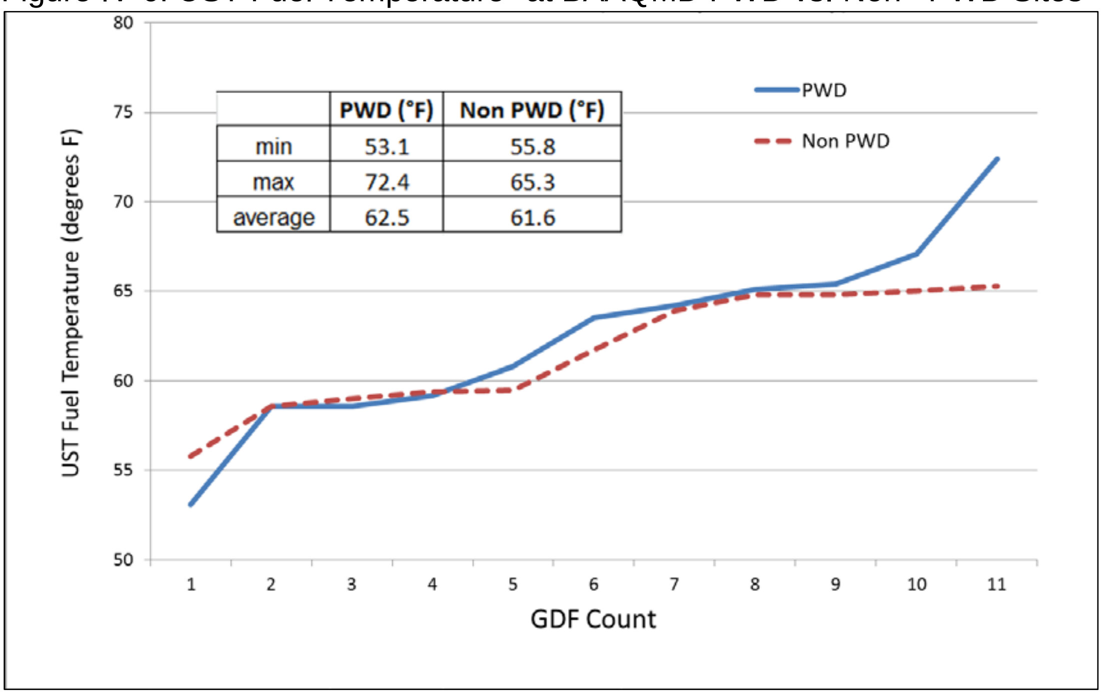
Figure IV-5: UST Fuel Temperature* at SCAQMD PWD vs. Non-PWD Sites



	PWD (°F)	Non- PWD (°F)
Min	61.3	64.4
Max	71.2	82.7
Average	68.0	69.4

*Average temperature of regular grade gasoline obtained during December 2013 ISD Download. Total of 42 Sites in SCAQMD (Assist systems only).

Figure IV-6: UST Fuel Temperature* at BAAQMD PWD vs. Non –PWD Sites



	PWD (°F)	Non PWD (°F)
min	53.1	55.8
max	72.4	65.3
average	62.5	61.6

*Average temperature of regular grade gasoline obtained during December 2013 ISD Download. Total of 22 Sites in BAAQMD (Assist systems only).

In examining site parameters that may have an effect on the occurrence of overpressure, staff looked at which sites included in the Mega Blitz had UST systems with secondary containment vacuum monitoring (SCVM). Table IV-9 looks at the number of sites included in the study equipped with a SCVM system that are assist or balance EVR system sites. Only 45 of the study sites, 11 percent of the total studied, are equipped with SCVM. Of those 82.2 percent are assist and 17.8 percent are balance EVR system sites.

Table IV-9: Prevalence of Sites Equipped with Secondary Containment Vacuum Monitoring

Overall	**With SCVM**	**Without SCVM**	**Total**
# of Sites in OP Blitz	45	350	395
% of Sites in OP Blitz	11%	89%	100%
# of Assist Sites	37	235	272
% of Assist Sites	82.2%	67.1%	68.9%
# of Balance Sites	8	115	123
% of Balance Sites	17.8%	32.9%	31.1%

Staff then compared the assist and balance EVR system sites with SCVM with sites that experienced at least one overpressure alarm from October 2013 to March 2014. Table IV-10 looks at this relationship, including the number of assist EVR system sites in the winter months that also experienced PWD. Overall, the population of sites with SCVM is low, but there is a slight increase in the number of overpressure alarms, but PWD did not differ in terms of frequency of alarms during the winter fuel months at assist EVR system sites.

Table IV-10: Overpressure Alarm Frequency at Sites Equipped with SCVM

	Assist			Balance		
October 2013	With SCVM	Without SCVM	Total	With SCVM	Without SCVM	Total
# of Sites with at least 1 OP alarm	5	19	24	0	2	2
% of Sites with at least 1 OP alarm	13.51%	8.09%	8.82%	0	1.74%	1.63%
December 2013						
# of Sites with at least 1 OP alarm	30	179	209	1	14	15
% of Sites with at least 1 OP alarm	81.08%	76.17%	76.84%	12.50%	12.17%	12.20%
# of Sites with PWD	13	80	93	0	0	0
% of Sites with PWD	35.10%	35.10%	34.19%	0	0	0
February 2014						
# of Sites with at least 1 OP alarm	23	152	175	0	8	8
% of Sites with at least 1 OP alarm	62.16%	64.68%	64.34%	0	6.96%	6.50%
# of Sites with PWD	6	57	63	0	0	0
% of Sites with PWD	16.20%	24.26	23.16%	0	0	0
March 2014						
# of Sites with at least 1 OP alarm	12	79	91	0	9	9
% of Sites with at least 1 OP alarm	32.43%	33.62%	29.04%	0	7.83%	7.32%

Prevalence of Sites with PWD

An examination of the data after the second round of data downloads in December 2013 indicated most sites experiencing PWD. The ISD data indicated that occurrences of PWD increased overall from 0 percent in October 2013 (summer fuel) to 24 percent in December 2013 (winter fuel). In December 2013, 34 percent of all assist sites and 0 percent of balance sites were experiencing instances of PWD, as shown in Table IV-11 below.

Table IV-11: Prevalence of PWD after Round 1 and 2 of ISD Downloads

Area	# of Stations Downloaded	# of Stations w/PWD in Oct 2013 (Summer Fuel)	# of Stations w/PWD in Dec 2013 (Winter Fuel)	% of Stations w/PWD in Oct 2013 (Summer Fuel)	% of Stations w/PWD in Dec 2013 (Winter Fuel)
All Counties – Overall	395	0	93	0%	24%
All Counties – Balance	123	0	0	0%	0%
All Counties – Assist	272	0	93	0%	34%

Staff analyzed the ISD data in regards to the prevalence of PWD during the switch back from winter to summer fuel in February/March 2014 and April/May 2014. The total number of GDF sites downloaded decreased from 395 to 391 sites due to site closures or problems connecting to the ISD. The third round of ISD data downloads in February 2014 indicated that 16 percent of all sites experienced PWD; equating to 23 percent of all assist sites and no balance sites, as shown in Table IV-12 below.

Table IV-12: Prevalence of PWD after Round 3 and 4 of ISD Downloads

Area	# of Stations Downloaded	# of Stations w/PWD in Feb/March 2014 (Winter Fuel)	# of Stations w/PWD in April/May 2014 (Summer Fuel)	% of Stations w/PWD in Feb/March 2014 (Winter Fuel)	% of Stations w/PWD in April/May 2014 (Summer Fuel)
All Counties – Overall	391	63	0	16%	0%
All Counties – Balance	121	0	0	0%	0%
All Counties – Assist	270	63	0	23%	0%

Leak Alarms - Site Type and PWD

Staff examined the relationship between the presence of leak alarms and EVR system type (assist or balance) and the presence of PWD. Table IV-13 depicts the prevalence of leak alarms at assist sites from October 2013 to November 2013. In October, 240 sites, 88.2 percent of the study sites did not experience a leak alarm. 19 sites, 7 percent, experienced only one leak alarm and 13 sites, 4.8 percent, experienced two or more leak alarms. In November, 91.2% of sites did not experience a leak alarm with only 18 sites, 6.6 percent, experiencing at least one alarm, and 8 sites, 21 percent, experienced two or more alarms. Table IV-14 examined the prevalence of leak alarms at balance sites. In October, 74 percent of the study sites did not experience a leak alarm. 11 sites, 8.9 percent, experienced only one leak alarm, and 21 sites, 9.7 percent, experienced two or more alarms. In November, 67.5 percent of sites did not experience a leak alarm with 19 sites, 15.5 percent, experiencing at least one alarm, and 21 sites, 17 percent, experiencing two or more alarms.

Table IV-13: Prevalence of Leak Alarms at Assist Sites

# of Leak Alarms (Oct 2013)	**# of Sites (Oct 2013)**	**% of Sites**	**# of Leak Alarms (Nov 2013)**	**# of Sites (Nov 2013)**	**% of Sites**
0	240	88.2%	0	248	91.2%
1	19	7.0%	1	18	6.6%
2	8	2.9%	2	2	0.7%
3	4	1.5%	3	2	0.7%
4	1	0.4%	4	2	0.7%
	272	**100%**		**272**	**100%**

Table IV-14: Prevalence of Leak Alarms at Balance Sites

# of Leak Alarms (Oct 2013)	**# of Sites (Oct 2013)**	**% of Sites**	**# of Leak Alarms (Nov 2013)**	**# of Sites (Nov 2013)**	**% of Sites**
0	91	74.0%	0	83	67.5%
1	11	8.9%	1	19	15.5%
2	7	5.7%	2	10	8.1%
3	5	4.1%	3	6	4.9%
4	7	5.7%	4	3	2.4%
5	1	0.8%	5	2	1.6%
6	1	0.8%			
	123	**100%**		**123**	**100%**

Table IV-15 examined the prevalence of PWD and leak alarms at sites. As of December 2013, there were 272 assist EVR sites. Of those, 93 were identified as PWD and 179 identified as non-PWD. The percentage of the PWD and non-PWD sites experiencing leak alarms fell for both from October 2013 to December 2013. The instances of leak alarms were higher in total at non-PWD sites.

Table IV-15: Prevalence of PWD and Leak Alarms at Assist Sites

Site Description	Size of Data Set	Time Frame	% of Sites with Leak Alarm
PWD	93 Sites	October 2013	10.8%
		December 2013	3.2%
Non-PWD	179 Sites	October 2013	12.3%
		December 2013	7.3%

<u>PWD and Throughput</u>

Staff using the VR Vapor Pressure Events P/U Plot and GDF operating characteristics captured in the field data form, examined the relationship at assist EVR system sites between the monthly gasoline throughput and PWD versus non-PWD sites. Table IV-16 shows the breakdown of assist sites with PWD from December 2013 to February 2014 in comparison to their average monthly gasoline throughput. The percentage of assist EVR system sites experiencing PWD decreased from December to February while average monthly gasoline throughput sites experiencing PWD increased during the same time frame. The decrease in instances of PWD cannot be attributed to this slight increase in average gasoline throughput, as throughputs fluctuate and the increase is less than ten percent.

Table IV-16: Assist Sites with PWD and Average Throughput

Download Date	December 2013	February 2014
Percentage of Healy Sites with PWD	34%	24%
Percentage of Healy Sites without PWD	66%	75%
Number of Healy Sites with PWD	93/272	67/272
Number of Healy Sites without PWD	179/272	205/272
Average Monthly Throughput at Sites with PWD	137,505	149,318
Average Monthly Throughput at Sites without PWD	225,604	210,967

Additionally, Figures IV-7 and IV-8 shows the relationship between the percentage of sites exhibiting PWD and monthly gasoline throughput from December 2013 and February 2014. A higher percentage of sites in the lower throughput ranges exhibit a higher percentage of PWD in December. In February 2014 sites in the lower throughput ranges were still exhibiting PWD, but the percentage was lower when compared to December.

Figure IV-7: PWD and Monthly Gasoline Throughput in December 2013

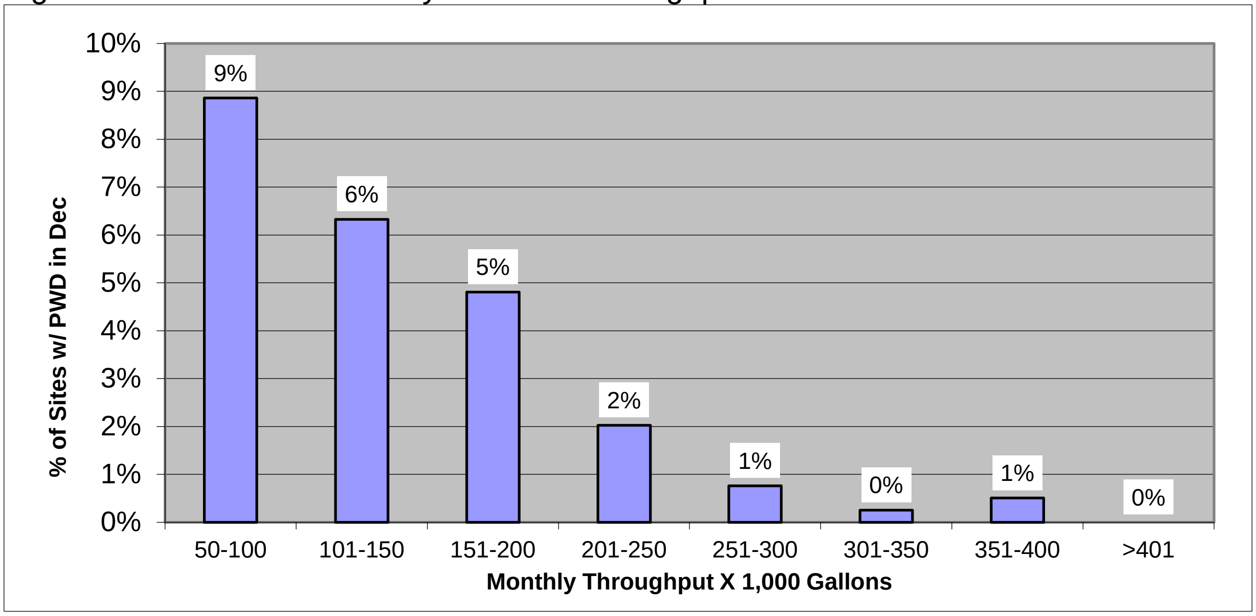
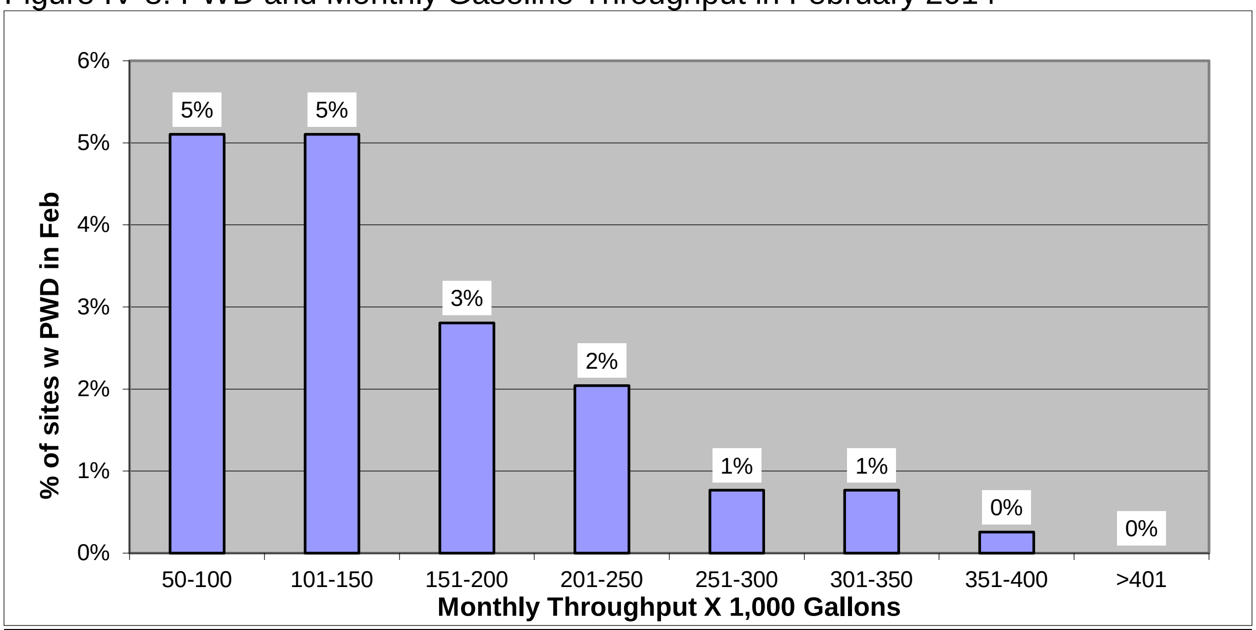


Figure IV-8: PWD and Monthly Gasoline Throughput in February 2014



PWD and Ullage Volume

Staff examined thirty assist sites located in SCAQMD; ten exhibiting PWD in December 2013 and February 2014; ten exhibiting PWD in December but not February; and ten not exhibiting PWD in December, but exhibiting it in February. The average throughput, UST capacity in gallons, and average ullage volume in gallons was also noted. Table IV-17 below shows that despite the varied stages of PWD, UST ullage was consistent at nearly 60 percent.

Table IV-17: Ullage Volume and Prevalence of PWD

Number of Sites	Average Throughput	PWD in Dec	PWD in Feb	Average UST Capacity (gallons)	Average Ullage Volume (gallons)	% Ullage
10	153,900	No	No	32,800	19,230	58.6%
10	134,900	Yes	Yes	32,700	18,790	57.5%
10	149,900	Yes	No	31,800	18,600	58.5%

V/L Ratios at PWD versus non-PWD Sites

To assess the effect of PWD on vapor to liquid (V/L) ratios of assist sites, staff used the HAT tool to compare the V/L ratios of PWD to non-PWD assist sites from October 2013, to December 2013 in four regions. Data was collected from 42 sites in South Coast, 22 sites in the Bay Area, 20 sites in San Diego, and 16 sites in the San Joaquin Valley. Each region studied contained an equal number of PWD and non-PWD sites as well as a similar monthly gasoline throughput at the GDFs. Table IV-18 below shows that the V/L ratios stayed relatively consistent from October to December 2013 at non-PWD and PWD sites. The V/L ratio at PWD sites was higher than at non-PWD sites.

Table IV-18: V/L Ratios of PWD and non-PWD Assist Sites

Date Data Collected	Region	Size of Date Set	Non PWD Site V/L Average	PWD Site V/L Average
October 2013	South Coast	42 sites	0.62	0.67
	Bay Area	22 sites	0.58	0.66
	San Diego	20 sites	0.60	0.62
	San Joaquin	16 sites	0.66	0.66
	Four Region	**Average**	**0.62**	**0.65**
December 2013	South Coast	42 sites	0.62	0.67
	Bay Area	22 sites	0.58	0.66
	San Diego	20 sites	0.61	0.65
	San Joaquin	16 sites	0.63	0.66
	Four Region	**Average**	**0.61**	**0.66**

Table IV-19 below takes the data from Table 19, the V/L ratios of PWD versus non-PWD sites and addresses assist EVR system sites that experienced neither overpressure nor leak alarms in October and December 2013. Staff obtained the V/Ls for four sites in South Coast, six sites in San Diego, and four sites in the Bay Area and compared their average V/Ls for October and December. Assist EVR system sites not experiencing overpressure and leak alarms had similar average V/Ls to non-PWD sites. The average V/Ls at PWD sites were higher across all three regions. This finding led staff to look more closely at the ORVR recognition of nozzles at study sites.

Table IV-19: V/L Ratios at Three Classifications of Assist Sites

Date Data Collected	Region	No OP & Leak Alarms Site V/L Average	Non PWD Site V/L Average	PWD Site V/L Average
October 2013	South Coast	0.60 (4 sites)	0.62 (21 sites)	0.67 (21 sites)
	San Diego	0.59 (6 sites)	0.60 (10 sites)	0.62 (10 sites)
	Bay Area	0.63 (4 sites)	0.58 (11 sites)	0.66 (11 sites)
	Average	**0.61**	**0.60**	**0.65**
December 2013	South Coast	0.59 (4 sites)	0.62 (21 sites)	0.67 (21 sites)
	San Diego	0.59 (6 sites)	0.61 (10 sites)	0.65 (10 sites)
	Bay Area	0.62 (4 sites)	0.58 (11 sites)	0.66 (11 sites)
	Average	**0.60**	**0.60**	**0.66**

Additionally, staff examined the V/L ratios of non-PWD (balance EVR system) sites in the four regions from October 2013, to December 2013. The changes in the average site V/L from October to December are shown below in Table IV-20. Each region showed a lower V/L ratio from October to December.

Table IV-20: V/L Ratios of Non-PWD (Balance) Sites

Region	PWD	# of Sites in Analysis	October 2013 V/L	December 2013 V/L
South Coast	No	14 sites	0.66	0.49
Bay Area	No	12 sites	0.63	0.51
San Diego	No	14 sites	0.61	0.49
San Joaquin	No	40 sites	0.60	0.50
Four Region Average			0.63	0.50

<u>ORVR Percentage and PWD</u>

Staff using the VR Vapor Pressure Events P/U Plot and the Assist Vapor Collection Test/Balance Flow Monitoring Test Results command examined the relationship at assist EVR system sites between the average percentage of ORVR vehicles (estimated by ISD) and PWD versus non-PWD sites. Table IV-21 shows the breakdown of sites with PWD from December 2013 to February 2014 in comparison to their vehicle ORVR percentage. The percentage of assist EVR system sites experiencing PWD decreased from December to February while ORVR percentage decreased slightly at sites with PWD.

Table IV-21: Assist Sites with PWD and ORVR Percentage

Download Date	December 2013	February 2014
Percentage of Healy Sites with PWD	34%	24%
Percentage of Healy Sites without PWD	66%	75%
Number of Healy Sites with PWD	93/272	66/272
Number of Healy Sites without PWD	179/272	205/272
ORVR% Average at Sites with PWD	48.1%	47.3%
ORVR% Average at Sites without PWD	53.1%	52.6%

Table IV-22 below shows the ISD estimate of ORVR percentage of the GDF sites, from the four regions discussed in the section above, compared between PWD and non-PWD. Each region studied contained an equal number of PWD and non-PWD sites as well as a similar monthly gasoline throughput at the GDFs. On average non-PWD sites experienced a slightly higher ORVR vehicle penetration percentage than PWD sites.

Table IV-22: ISD Estimate Site ORVR Percentage at Non-PWD vs. PWD Sites

Region	**Size of Date Set**	**ORVR % Site Average**	
		Non PWD	**PWD**
South Coast	42 sites	51.6%	49.2%
Bay Area	22 sites	56.1%	47.8%
San Diego	20 sites	53.3%	46.9%
San Joaquin	16 sites	48.5%	48.7%
Four Region Average		**52.4%**	**48.2%**

V: Discussion of Results

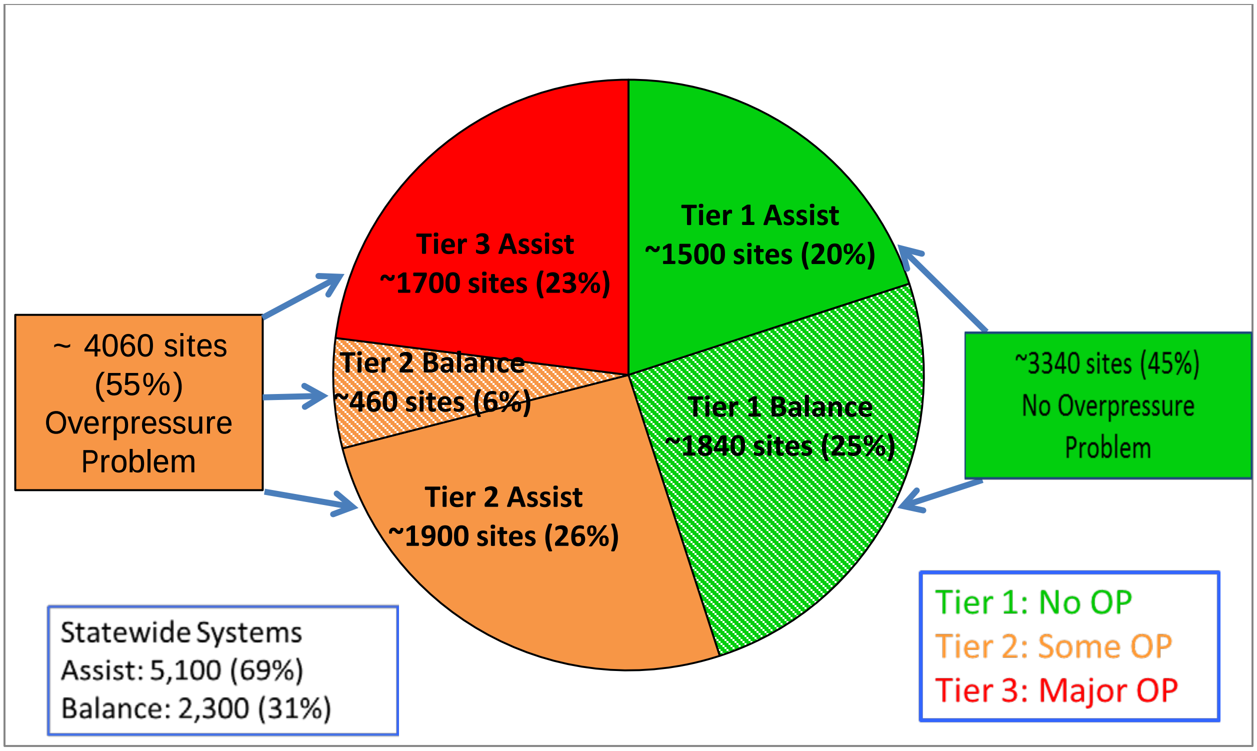
After data analysis was completed, staff worked to identify trends and correlations derived from the Mega Blitz of 2013/2014 study. The data indicates that the severity of overpressure occurrences for each site differs based upon whether a site possesses an assist or balance EVR system. Additionally, the severity of overpressure among assist sites is further defined due to the occurrence/existence of PWD. To better describe the severity of the overpressure issue, staff introduced the concept of Tier 1, 2, and 3 classifications (see Table V-1 below), and examined their distribution between assist and balance EVR system equipped sites. Tier 1 is the level at which no overpressure conditions exist. Tier 2 is the level at which overpressure conditions exist, but where PWD does not. The efficiency loss at Tier 2 sites is assumed to be less than 5 percent in the winter. Tier 3 is the level at which overpressure conditions exist with PWD. The efficiency loss at Tier 3 sites is assumed to be greater than 5 percent in the winter due to pressure driven fugitive and vent line emissions.

Table V-1: Tiers of Overpressure Severity within Mega Blitz Sample Population

Severity of Overpressure Condition	Assist Equipped Sites	Balance Equipped Sites
Tier 1: No ISD Overpressure Alarms	Population: ~20% • No efficiency loss	Population: ~25% • No efficiency loss
Tier 2: ISD Overpressure Alarms - Non PWD	Population: ~26% • Less than 5% efficiency loss in winter time	Population: ~6% • Less than 5% efficiency loss in winter time
Tier 3: ISD Overpressure Alarms and PWD	Population: ~23% • Efficiency loss greater than 5% in winter time • Increased reactive organic gas emissions in winter • Potential health risk due to benzene exposure	Population: None

Figure V-1 was developed to illustrate the estimated statewide scope of the overpressure alarm problem, assuming that the data collected in the Mega Blitz of 2013/2014 is representative of the entire statewide population of GDF. In order to be considered "Tier Three", it means that PWD was present during the December 2013 segment of the field study. If one were to extrapolate the results of the Mega Blitz on a statewide basis the percentages provided in Figure 18 can be applied. Statewide, there are approximately 7,400 GDF equipped with Phase II EVR and ISD. 69 percent (5,100) of GDFs have assist EVR systems installed, while 31 percent (2,300) of GDFs have balance EVR systems. Tiers 2 and 3, meaning those sites experiencing the overpressure problem, include approximately 4,060 GDF sites; Tier 3, major overpressure, includes 1,700 sites (23 percent of the total population). All GDFs experiencing major overpressure in Tier 3 are assist EVR system sites.

Figure V-1: Scope of the Overpressure Alarm Problem Statewide Estimate



The key findings identified from the Mega Blitz are as follows:

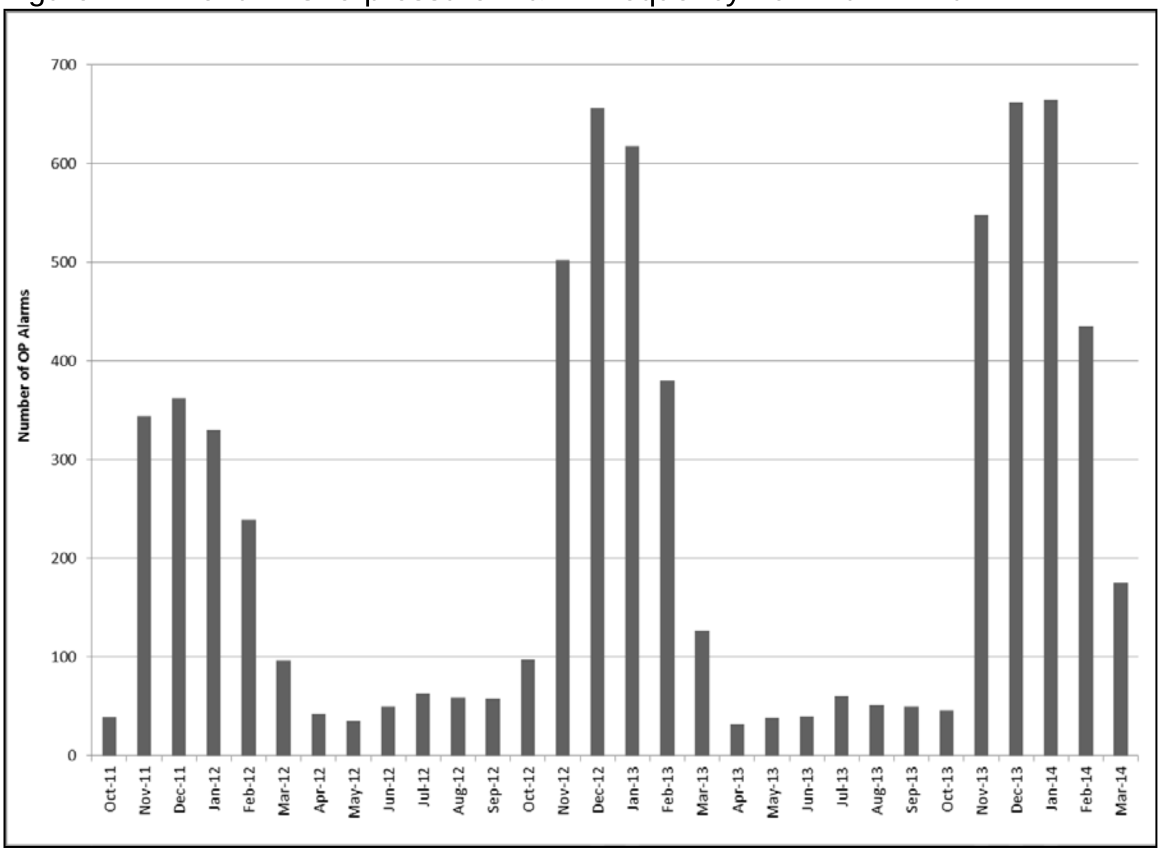
- Overpressure is a winter time phenomena that is associated with uncontrolled RVP fuel. Summer time overpressure alarms are a fraction of those that occur during the winter fuel season.
- During the winter fuel season, PWD exists at approximately 34 percent of the assist EVR system sites. No balance EVR system sites show PWD, indicating that there is either something fundamentally different about the assist system that causes overpressure, or something unique about the balance system that affects site pressure profiles.
- During winter fuel season, PWD assist EVR system sites exhibit a higher V/L ratio when compared to non-PWD assist sites, suggesting that air ingestion by mis-identification of ORVR vehicles into the system is a key contributor.
- During winter fuel season, balance EVR system sites have a lower V/L ratio when compared to assist sites. This suggests that balance sites have less air ingestion and either less emissions or emissions are being released at the nozzle-fill pipe interface but are not captured by ISD. Balance emissions not captured by ISD are documented in Report Number VR-OP-B2.
- Overpressure alarm frequency increases in the winter time, every year by approximately 20 percent, suggesting that the trend is worsening over time. This may be related to vehicle fleet turn-over, as more ORVR vehicles are introduced, and may suggest the vehicle fill pipe design for new vehicles may have changed.
- Leak alarm frequency is relatively low for assist EVR systems, but occurring at approximately 25 to 30 percent of balance EVR system sites. This suggests that

balance systems may have a durability issue with hanging hardware, such as hoses and breakaways.

- The percentage of sites with leak alarms decreases with the introduction of wintertime fuel for both PWD and non-PWD sites. This suggests that the higher evaporation rate of high RVP fuel factors into masking system leaks.

The Mega Blitz of 2013/2014, and data downloaded before and after, have shown not only that overpressure alarms consistently occur during winter fuel months, but that their frequency is increasing by approximately 20 percent each year. Figure V-2 shows the trend of increasing overpressure alarm frequency from October 2011 to November 2014. The number of overpressure alarms in November, the first month of the winter fuel season, of each year from 2011 to 2014 increases.

Figure V-2: Trend in Overpressure Alarm Frequency from 2011 – 2014



Many factors contribute to overpressure occurrences at GDFs. The primary cause is uncontrolled Reid Vapor Pressure (RVP) of gasoline available in the winter months from November to March. Wintertime fuel RVP is higher than that of summertime fuel and leads to greater volatility, higher UST system pressure, and greater emissions.

While wintertime uncontrolled RVP is the underlying driver for overpressure alarms, there are a number of factors that contribute to the total problem. Secondary causes can include:

- Type of Phase II EVR system (assist versus balance);
- Excess air ingestion when fueling ORVR equipped vehicles;
- Monthly gasoline throughput;
- GDF maintenance practices; and
- GDF operating hours (24 hr sites versus those that shut down at night).

ARB cannot control secondary factors such as monthly throughput, maintenance practices, or operating hours, but it can address the effectiveness of Phase II EVR systems including potential causes of excess air ingestion.

Data analysis of all four rounds of the Mega Blitz of 2013/2014 demonstrated the prevalence of PWD during winter fuel months. Round II in December 2013 showed 93 out of 395 sites exhibiting PWD. Round III in February 2014 showed 63 out of 391 sites exhibiting PWD. This is a significant increase from no GDFs in October 2013 (summer time fuel) exhibiting PWD.

It was hypothesized that a main cause of PWD at GDFs is over collection due to the assist nozzle. Over collection occurs when the nozzle's V/L ratio is adjusted too high, or if the nozzle does not properly recognize ORVR vehicles (shifted nozzles). It was also hypothesized that shifted nozzles cause the PWD condition seen at some GDF sites. A shifted nozzle is one with a high percentage of fueling event V/L ratios between 0.5 and 0.8. Additionally, the lack of system ORVR recognition is also attributed as a cause for PWD due to excess air ingestion. As these three hypotheses were outside of the scope of the Mega Blitz of 2013/2014, they were addressed in follow-up CARB studies summarized in other technical support documents.

In this study, staff observed that the V/L ratios at balance EVR system sites decreased during winter fuel months. During the study it was seen that balance sites do not experience PWD. During summer fuel months, balance sites exhibit similar V/L ratios when compared to assist systems, however, during winter fuel months, the balance systems exhibit a significantly lower V/L when compared to assist system sites (see Table V-2 below). The decrease in V/L ratios for balance system sites may be the result of less air being returned to the UST, resulting in less air ingestion than in assist sites, providing an explanation for the difference in the pressure profiles of assist and balance systems. Additionally, the higher pressure in the ullage due to wintertime gasoline could contribute to the lower V/Ls for balance systems.

Table V-2: V/L Ratios at Balance Sites

Location	Date	V/L
San Diego 12 Sites	October 2013	0.63
	December 2013	0.51
South Coast 12 Sites	October 2013	0.60
	December 2013	0.50

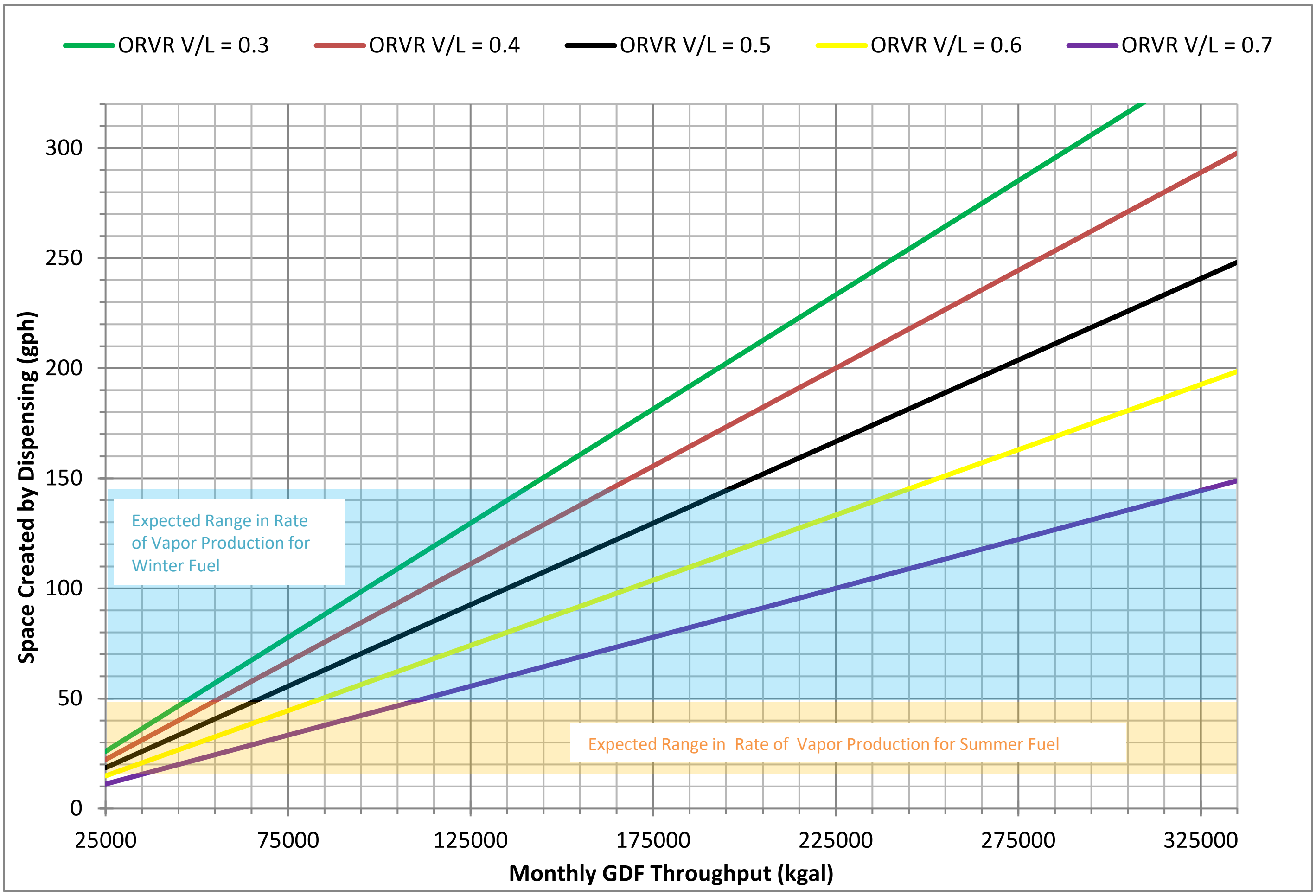
While examining GDF throughput and comparing it to the prevalence of PWD, staff discovered there is an inverse relationship between throughput and PWD (see Table V-3 below). PWD is most likely to occur at GDF with a throughput less than 200,000 gallons/month. Additionally, PWD does not occur at GDF with a throughput greater than 400,000 gallons/month.

Table V-3: Throughput Range and Prevalence of PWD

Throughput Range (in 1000 gallons)	**# of Sites in Dec 2013**	**# of Sites with PWD in Dec 2013**	**% of Sites with PWD in Dec 2013**
50-100	105	35	33.3%
101-150	99	25	25.3%
151-200	83	19	22.9%
201-250	49	8	16.3%
251-300	25	3	12.0%
301-350	10	1	10.0%
351-400	6	2	33.3%
>401	18	0	0.0%
Total	395	93	23.5%

An examination of the data on ORVR V/Ls and the relationship between a GDF's monthly gasoline throughput and the space created in the UST by dispensing and the vapor production rate, or evaporation rate, from summer to winter fuel can indicate when PWD would be expected to occur. In Figure V-3 GDFs with different ORVR V/Ls can be expected to experience PWD if the rate of space created by dispensing is less than the rate of vapor produced by evaporation of the high RVP wintertime fuel. In the winter fuel period, a GDF with an ORVR V/L of 0.5 and a monthly throughput of 175,000 gallons would have a space created by a dispensing rate of 130 gallons per hour. This would be below the rate of vapor produced by evaporation, which is approximately 180 gallons per hour, therefore creating PWD.

Figure V-3: Space Created by Dispensing as a Function of Throughput and ORVR V/Ls



*Assumptions: non-ORVR V/L = 1; 20 percent dispensed to non-ORVR; constant dispensing rate 18 hours per day; zero leak rate.

Note: Space created in UST by dispensing as a function of GDF throughput and ORVR V/L. PWD will occur if rate space created is less than the rate vapor produced by evaporation. If leaks exist, a higher evaporation rate will be necessary to produce PWD. Allowable leak rate at 2" WCG is in the range of 30 to 50 gph.

Along with GDF gasoline throughput and V/L, staff examined if there existed a relationship between low product volumes in the UST the existence of PWD. It was hypothesized that low product volume (high UST ullage volume) would expose the submersible turbine pump return line in a manner that would cause ‘splash loading’ and accelerate the evaporation rate. Staff examined thirty assist sites located in SCAQMD, exhibiting varying stages of PWD from December 2013 to February 2014, all with similar UST capacity and ullage volumes. Staff found that no matter the stage of PWD, the ullage was consistent at nearly 60 percent.

The relationship between UST capacity and the existence of PWD was also examined. Data showed that the majority of PWD (71 percent) occurs at sites with UST capacities of between 20 to 30 thousand gallons. Additionally, the data showed that the majority of non-PWD sites (56 percent) also have USTs with a capacity between 20 to 30 thousand gallons. This indicates that a majority of USTs have a capacity of 20 to 30 thousand gallons and not that a relationship exists between UST capacity and the existence of PWD.

Staff also examined data to investigate the hypothesis that sites exhibiting overpressure and PWD could be tied to specific brands of gasoline (e.g. Chevron, Shell, ARCO, 76, Exxon/Mobil, etc.) or to specific loading terminals (e.g. Chevron-Richmond, Kinder Morgan-Colton, Tesoro-Carson, etc.). Staff pulled fuel delivery invoices (bill of ladings) obtained from GDFs during the December 2013 Mega Blitz download round, when PWD was most prevalent. The “bill of ladings” were pulled from 58 and 133 GDFs in BAAQMD and SCAQMD, respectively, and staff looked for links between fuel brand and terminal origin and the occurrence of PWD. No links could be found between PWD and gasoline brand and origin. In both districts sites with PWD and sites without PWD were receiving fuel from the same suppliers and same terminals during the same time frames.

VI: Conclusion and Recommendation

Upon completion of the study and data analysis, CARB staff is able to reach the following conclusions:

1. Both the causes and the likely solutions to the overpressure alarm issue are more complex than previously thought.
2. Although winter time fuel RVP is the underlying driver for the overpressure alarm phenomenon, there are a number of factors that contribute to the problem. Other factors contributing to the overpressure problems include:
    a. The type of GDF nozzle – 70 percent of GDFs with assist systems experience wintertime overpressure alarms while only 20 percent of stations with balance systems experience wintertime overpressure alarms.
    b. GDF operating hours – Stations that shut down at night are more likely to experience overpressure.
    c. Gasoline throughput – Stations with low throughput are more likely to experience overpressure.
    d. Vapor to liquid ratio of fueling transactions. GDFs with an elevated vapor to liquid ratio are more likely to exhibit overpressure alarms and PWD.
3. While the exact cause of PWD has not been determined, the study and data analysis has shown that the following have no effect on PWD:
    a. Gasoline branding;
    b. Potential splash loading resulting from secondary containment vacuum monitoring;
    c. The existence of low product volume or high ullage; and
    d. Gasoline temperature.
4. One of the trends that has become apparent over three years of field study is that the frequency of overpressure alarms has been increasing. The cause of this overpressure alarm increase is not clear but may be related to the increasing penetration of ORVR-equipped vehicles and the design of their fill pipes (which is an on-going CARB investigation).

Following the conclusion of the Mega Blitz of 2013/2014, CARB staff has the following recommendations for additional field study:

1. Conduct an ORVR recognition study to understand whether compatibility with the nozzles has changed with ORVR vehicles (Report Numbers VR-OP-A3, VR-OP-A4, VR-OP-A5, and VR-OP-A7);
2. Quantify emissions from assist sites exhibiting PWD (Report Number VR-OP-A6; and
3. Quantify emissions from balance sites with systems at positive pressure (Report Number VR-OP-B2).

VII: Appendices

Appendices available upon request.