UNITED STATES DEPARTMENT OF INTERIOR

GEOLOGICAL SURVEY

Underwater Gravity Meter Survey of San Francisco and San Pablo Bays, California, 1982

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(1) All at Menlo Park, California

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Abstract

Seafloor gravity measurements were made at 281 bottom stations in San Francisco and San Pablo Bays, California, on a series of lines oriented approximately NNE. Line spacing was approximately 2.8 km and stations along the lines were spaced 0.5 to 1.5 km apart. between 0.5 and 1.5 km perpendicular to the axis. Simple Bouguer anomalies in the San Francisco Bay range from -15 to +15 mGals (±0.1 mGal), while anomalies in the San Pablo Bay are consistently negative, ranging from +4.0 to -40.0 mGal (±0.2 mGal).

I. Introduction

A high precision underwater gravity survey of the San Francisco and San Pablo Bays was conducted from a 32 foot shallow draft research boat, the R/V David Johnston, over a three month period (March-May 1982) in cooperation with the U.S. Defense Mapping Agency Hydrographic Topographic Center (DMAHTC). This report includes a description of the methods of data collection; a summary of the data processing, including program listings; a listing of the survey results; and an analysis of the survey errors.

II. Data Collection

Gravity and water depth measurements

All gravity measurements were made with one of two Model H LaCoste and Romberg underwater gravity meters (H9G and H10G). These meters were mounted in a standard pressure housing attached to a submersible platform. This package was lowered and raised by a wire line winch, and was equipped with oversized feet to improve stability and minimize sinking of the package into the bay mud. The gravity meter was remotely operated through a multiconductor cable. The first and last gravity measurements each day were taken at one of three dockside reference stations (Redwood City, San Pablo, and San Francisco, Figure 1 and Table 1). These reference stations were tied together and to the DMAHTC California gravity net (DMA, 1982), with a LaCoste and Romberg Model G land gravity meter. After the survey, the proper calibration and performance of gravity meter H10G was verified by reading the meter over a known calibration loop at nearby Mt. Hamilton. Gravity meter H9G malfunctioned during the survey, and therefore could not be read over this calibration loop. However, measurements with H9G and H10G at identical stations indicated that H9G was functioning properly during the period of time that it was used.

Water depths in the survey area ranged from 0.7 to 33.5 meters, and were measured by means of a pressure transducer whose output was filtered to remove the effects of chop and surge of the water surface. The pressure transducer had an estimated accuracy of ±0.08 meters. Water depths were also measured with a mechanical probe in water less than 3 meters.

Navigation

Gravity stations were located with a Del Norte range-range transponder navigation system. Transponder locations are given in Table 2. Prior to the survey, all transponders were calibrated over an 1100 meter test range, established with a laser ranging device accurate to within 3 cm. Simultaneous ranges from three to five transponders were used for station positions. The transponder and gravity station locations were preplotted before the survey, and the ranges from the transponder locations to the preplotted gravity stations calculated. During the survey, these precalculated ranges were used to position the boat as close as practical to the preplot location of the gravity station. Observed ranges were recorded as the gravity meter was lowered and read. Up to five transponders were available for location determination, but generally only three or four were useful for locating for a given station (i.e. line of sight from the boat to the transponder was uninterrupted). Also, when the angle defined by the intersection of lines from the gravity station to each of two transponders was less than 15 degrees or greater than 165 degrees, small errors in the measured ranges produced large positional errors. Such transponder pairs were not used. Therefore, three or six solutions (three or four transponders used two at a time) were available for each location calculation. Spurious points (determined by visual inspection of location plots) were discarded, and the final location determined by least squares from the remaining points. Table 3 includes for each station the calculated position (in geodetic coordinates), the number of points used in the calculation, and the variance (the root mean square distance between all pairs of solutions) associated with that position.

As an estimate of the navigational accuracy, repeated measurements at five stationary navigational markers are shown at the end of Table 3. Table 4 provides a rough summary, showing the x and y standard deviations, and maximum mean variance for each set of solutions. Since the variance of the position is the rms distance between each pair of fix positions, it is divided by two for comparision with the standard deviation. This table shows that the variance listed in Table 3 provides a good estimate of the standard deviation. Of 249 variances calculated, 71% were less than 10 meters, and 99% were less than 20 meters. The highest variance was 90 meters.

Water tide measurements

The height of the gravity meter relative to a reference datum (here North American Datum 1927, NAD27) must be known to reduce masured gravity values to free-air and Bouguer anomalies. Because water depth beneath the sea surface was recorded during the survey, gravity meter depth relative to NAD27 required knowledge of the tidal height at the time of measurement. This geometry is illustrated in Figure 2. Because the maximum water tidal range in San Francisco Bay is 3 meters, the tidal correction is as large as 1 mGal. (The free-air correction in seawater is -0.3086 mGal/meter. The tidal height must therefore be known to within 30 cm, or about 1 foot, to maintain a desired accuracy of 0.1 mGal.

Tidal heights were calculated by two methods. For all stations south of the San Francisco-Oakland Bay Bridge (see Figure 1), tidal heights were interpolated from tide gauges located at Golden Gate, Alameda, San Mateo and Guadalupe Slough, where hourly tide measurements were available (quarter-hourly for Guadalupe Slough). Tidal height at each gauge at the time of the gravity reading was determined by linear time interpolation between the hourly or quarter-hourly values. Tidal variations (phase and amplitude changes) propogate along the axis of the Bay (Ralph Cheng, 1983, personal communication), and are hence independent of the off-axis component of station location. Therefore tide height at a gravity station was determined by interpolation between the bracketing tide gauge locations, after projecting the station and gauge locations perpendicularly to the axis of the bay. The accuracy of this method was tested by computing values for San Mateo by interpolation between Alameda and Guadalupe, and comparing these interpolated values with those actually measured at the San Mateo gauge. The calculated values showed excellent agreement with the observed values (Figure 3), except for lower-low tides, when the predicted values were as much as +0.8 feet too large. Because the interpolations used to establish the tidal height at the gravity stations were calculated over approximately half the distance for this test, the predicted tide height should be in error by less than 0.5 feet.

A less precise method was required to establish tidal heights north of the Bay Bridge, because the only existing tide gauge in the area for the period of interest was near the Golden Gate at Fort Point. This method used the tide values at Golden Gate, and the phase and amplitude differences between Golden Gate and positions around the perimeter of the Bay for higher-high and lower-low tides, published by NOAA (1982). The total tide variation between higher-high and lower-low tides was known for this time period, and it was assumed that the time delay and amplitude difference for a particular tide relative to Golden Gate could be interpolated between the values for higher-high and lower-low tide. This method was tested for San Mateo and Guadalupe Slough in the south San Francisco Bay, points where actual tide data existed, and those results indicated two necessary refinements. First, the phase delays from Golden Gate predicted by the NOAA tables appear to be about 40% too great at higher-high and lower-low. Secondly, the NOAA tables indicated that the magnitude of lower-low tides did not differ from Golden Gate, whereas the comparison of actual data showed that lower-low tides are actually a foot or two lower in the far reaches of the south San Francisco Bay than at Golden Gate. With these refinements, the errors in the predicted values for San Mateo were reduced to less than 1 foot, and for Guadalupe to less than 1.5 feet. Maximum errors occurred at low and lower-low tides (Figure 4). Assuming an admittedly questionable symmetry between the north and south bays (1), these same refinements were used to predict tides for north San Francisco and San Pablo Bay. Tidal values in the north San Francisco Bay are presumed to be accurate to within 1 foot, and in San Pablo Bay to within 2 feet.

III. Gravity reduction

Observed gravity readings were adjusted for gravity meter calibration, and corrected for gravity fluctuations due to tides, and instrument drift. The latter was assumed to be linear over time between base station readings at the beginning and end of each survey day. Corrected gravity readings were adjusted to the absolute value of gravity at the base station at Redwood City, which was tied to the DMAHTC California gravity net (Table 1). Free-air and simple Bouguer gravity anomalies were calculated with respect to the 1967 Geodetic Reference System according to accepted convention for underwater stations (Garland, 1965, p. 58; Hittelman and others, 1982). The observed gravity values were reduced to the NAD27 datum by applying a free-air correction (-0.3086 mGal/meter) and a double Bouguer slab correction (+0.0864 mGal/meter, assumed sea water density 1.03 g/cc) to correct for sub-sea level elevations; and a single Bouguer slab correction to account for deviations of tidal height from NAD27. Schematic illustrations of the possible geometries and reduction equations are shown in Figure 2. Average rock density of 2.22 g/cc and sea water density of 1.03 g/cc were used throughout the calculations. The FORTRAN program listed in Appendix A was used to perform the reduction. The results are tabulated in Table 3. Terrain (Dehlinger, 1978) were not performed.

IV. Errors

Three factors contribute to errors in the free-air and Bouguer anomalies: errors in the gravity measurements, errors in geographic position, and errors in depth measurements and tidal height calculations. The repeatability of several instrumental functions connected with remotely operated gravity meters (Beyer and others, 1966) and misclosures of base station ties affect the errors in observed gravity values. The gravity meter and its remote control system operated optimally during the survey, and instrument drift (as indicated by misclosures of base station ties) was the principal source of error in the observed values. Of 27 daily gravity loops made during the survey, 23 were closed to within 0.1 mGal and 4 were closed between 0.1 and 0.2 mGal after earth tide corrections were applied. Misclosure errors were distributed linearly with time, and the resultant errors in

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(1) One relevant difference is that tides in the south bay consist of progressive waves, where peak velocity leads peak amplitude by 90 degrees. In the north bay the tides are forced waves, and there is no phase difference between peak velocity and amplitude. (Ralph Cheng, 1983, personal communications.)

observed gravity values are believed to be not more than 0.02 mGal.

Errors in navigational positioning are discussed above. Using the 1967 reference ellipsoid in the vicinity of 37.5 degrees N latitude, the error introduced by a ten meter N-S shift is 0.009 mGal.

Cumulative elevation errors derived from errors in measured water depth (±0.008 m) and errors in estimated tidal height (± 0.15 m in the south San Francisco Bay, ± 0.30 m in north San Francisco Bay, and ± 0.60 m in San Pablo Bay) yield maximum probable gravity anomaly errors of:

	free-air anomaly error (in mGals)	Bouguer anomaly error (in mGals)
South San Francisco Bay	±0.07	±0.06
North San Francisco Bay	±0.12	±0.10
San Pablo Bay	±0.21	±0.19

Twelve stations were reoccupied during the survey to check the repeatability of the navigational system and the gravity measurements (Table 3, Table 5). Table 5 lists the differences in position, height and free-air value. Any comparison of the gravity values in this table must be cautious, because the initial gravity readings at these stations were not closed to a base station, due to accidental damage to the gravity meter and power cable by the vessel. Therefore, the gravity values listed in the table under "REMEASURED STATIONS" were not corrected for meter drift. This problem was compounded because one of the meters used was subject to abnormally high drift rates. The first nine stations in Table 5 were collected over a four hour period on May 5, and are arranged chronologically. The free-air values, compared with subsequent measurements at the same stations, are characterized by increasingly large discrepancies. Fitting the errors by linear regression against time, a drift rate of -0.13 mGal/hour is calculated. This is extremely high (two orders of magnitude greater than the LaCoste and Romberg technical specifications), but as Figure 5 shows, the linear fit is quite good. A similar regression was performed on three stations (aa18, bb18, bb17) collected on May 3, with a resulting drift of -0.08mGal/hr, smaller but still very large. If the stations are corrected for this presumed gravity meter drift, the agreement between these stations and subsequent remeasurement is within the ± 0.2 mGal predicted above. (All of the repeated stations were in San Pablo Bay). The largest differences (bb6 and bb2) can be accounted for almost entirely by differences in position, due to the gradients shown at the bottom of the table. The differences in stations bb7 and dd1 can be attributed entirely to the errors in measuring station height, (i.e. tidal height), thus confirming this factor as the largest source of error.

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Figure Captions

Figure 1. Index map of the San Francisco and San Pablo Bays indicating locations of gravity stations navigational transponder sites, and tide gauges used to predict tides in the bay complex.

Figure 2. Schematic diagram illustrating the relation between observed water depth (d), tidal height of the water (t), and elevation of the gravity meter relative to NAD 1927 (h). The equations at the bottom represent the gravity reduction formulas for free-air and simple Bouguer anomalies in the cases of positive, zero, and negative tidal heights relative to the datum.

Figure 3. Errors in tide height at San Mateo predicted by interpolation between measured values at Alameda and Guadalupe Slough (see Figure 1).

Figure 4. Error in tide height at San Mateo and Gaudalupe Slough predicted by extrapolation from Golden Gate using refined amplitude and phase differences from NOAA (1982).

Figure 5. Difference in the free-air anomalies for proximate station locations measured on May 3 and 5, when the meter was not corrected for drift, and subsequently remeasured; as a function of time of day.

Appendices

Appendix A. Listing of Fortran program used to calculate free-air and Bouguer anomalies.

Appendix B. Listing of Basic program written for Tektronix 4054 to calculate tides for the north San Francisco and San Pablo Bays.

TABLE 1
Selected California Gravity Base Stations

Station Name	DMA ID	Latitude	Longitude	Ht(m)	IGSN71 (mGal)
Redwood City	121G32	37.5048 N	-122.2183 W	3.0	979,954.036
San Francisco	121G34	37.8100 N	-122.4092 W	3.0	979,981.366
San Pablo	121G33	37.9622 N	-122.4180 W	3.0	979,990.703

TABLE 2
Navigational Transponder Location Descriptions

Station Name	UTM zone	Ht (ft)	Latitude	Longitude	UTM(y) (meters)	UTM(y) (meters)
Albany transponder	10	190	37.89083	-122.30393	561205.40	4193725.41
Atkinson 2	10	358	37.52238	-121.93971	593694.40	4153148.00
Baker 2	10	925	37.83741	-122.48932	544936.20	4187694.09
Building 253	10	98	37.72670	-122.35791	556583.70	4175481.59
C.S.M. Bldg.	10	699	37.53706	-122.33545	558712.20	4154456.19
Cross	10	900	37.45695	-122.27099	564476.20	4145610.91
Dish	10	489	37.40696	-122.17811	572739.30	4140133.00
Green Hill 2	10	63	38.20182	-122.28813	562329.70	4228241.50
Grove Point 2	10	62	38.01326	-122.48605	544940.40	4207204.81
Hat	10	85	37.66269	-122.12018	577600.70	4168550.19
Manzanita Ca Dpt Hwy	10	406	37.87515	-122.51946	542262.50	4191866.31
Mare Island Southeast	10	282	38.07676	-122.25392	565436.80	4214388.81
Mission Rock SE corner li	10	12	37.77204	-122.38044	554565.00	4180499.00
Point Pinole 4	10	69	38.01170	-122.36564	555687.50	4207098.13
Point San Bruno	10	180	37.65335	-122.38383	554352.60	4167329.41
Richmond Pier SW Corner	10	30	37.90859	-122.38653	553928.60	4195645.00
Ring	10	604	37.90976	-122.48469	545299.10	4195723.00
San Quentin 2	10	40	37.94392	-122.48195	545518.80	4199514.63
Sears Point	10	59	38.13978	-122.44454	548676.00	4221264.00
Soupy	10	1898	37.56148	-122.47649	546235.50	4157086.59
Sunrise Cross	10	648	37.83414	-122.22873	567869.20	4187487.91
Turk Ref Marker 1	10	9	37.80610	-122.45281	548168.80	4184237.91
Y.B.I. Lookout Tower	10	341	37.80987	-122.36496	555899.80	4184705.50

TABLE 3

San Francisco and San Pablo Bays
Gravity Survey Data

Data record contains:

YR	year
D	julian day
H,M	time (hours, minutes)
LAT	latitude (decimal degrees)
LONG	longitude (decimal degrees)
STA	station identifier
GOBS	observed gravity (mGals)
G67	theoretical gravity (mGals)
FAA	free-air anomaly (mGals)
DPTH	depth below sea surface (feet)
BGA	Bouguer anomaly (mGals)
TIDE	tide height relative to North American Datum 1927 (feet)
NPT(1)	number of navigational fixes used in positional solution
NPT(2)	number of navigational fixes available at station location
VAR	variance of positional solution (meters)
MODAY	month and day
CRUISE	USGS cruise identifier

YR	D H M	LAT LONG	STA	GOBS	G67	FAA67	DPTH	BGA	TIDE	NPT	VAR	MODAY	CRUISE
82	821014	3745697-12208946	a1	979941.09	979944.59	-3.58	2.0	-3.54	1.3	5 6	5.0	MARCH 23	j482sf
82	82104C	3746063-12208182	a2	979941.63	979944.91	-3.40	2.2	-3.35	1.4	3 6	5.4	MARCH 23	j482sf
82	8211 3	3746527-12207389	a3	979941.90	979945.32	-3.54	2.2	-3.48	1.4	4 6	28.1	MARCH 23	j482sf
82	821122	3746912-12206680	a4	979940.35	979945.65	-5.49	2.5	-5.41	1.4	4 6	9.5	MARCH 23	j482sf
82	82115C	3747307-12205937	a5	979939.75	979946.00	-6.34	2.0	-6.29	1.3	4 6	7.7	MARCH 23	j482sf
82	821231	3746941-12211020	b1	979943.94	979945.68	-1.78	1.5	-1.75	1.1	4 6	13.8	MARCH 23	j482sf
82	8213 1	3747387-12210232	b2	979944.45	979946.06	-1.75	1.7	-1.70	0.9	2 3	0.0	MARCH 23	j432sf
82	821322	3747810-12209505	b3	979943.90	979946.44	-2.74	1.7	-2.67	0.7	2 3	0.0	MARCH 23	j482sf
82	821344	3748171-12208750	b4	979944.46	979946.74	-3.40	5.6	-3.05	0.5	2 3	0.0	MARCH 23	j482sf
82	8214 7	3748688-12207980	b5	979944.10	979947.21	-4.02	4.5	-3.74	0.3	3 6	8.2	MARCH 23	j482sf
82	821419	3749087-12207215	b6	979943.39	979947.54	-4.37	1.2	-4.30	0.2	2 6	0.0	MARCH 23	j482sf
82	831243	3749572-12206544	b7	979943.25	979947.96	-4.68	1.5	-4.67	1.4	5 6	90.2	MARCH 24	j482sf
82	831327	3748572-12212062	c1	979947.21	979947.09	0.08	1.5	0.10	1.1	4 6	18.1	MARCH 24	j482sf
82	831351	3748872-12211436	c2	979947.04	979947.35	-0.46	1.7	-0.40	0.9	5 6	12.3	MARCH 24	j432sf
82	831414	3749311-12210906	c3	979947.52	979947.75	-0.86	3.7	-0.65	0.7	5 6	65.6	MARCH 24	j432sf
82	821511	3749562-12210364	c4	979949.62	979947.96	-1.27	12.8	-0.37	-0.3	2 6	0.0	MARCH 23	j482sf
82	831439	3749804-12209813	c5	979948.75	979948.17	0.49	0.9	0.53	0.4	5 6	12.5	MARCH 24	j482sf
82	841421	3750556-12212561	d1	979949.79	979948.84	0.83	1.7	0.88	1.0	3 6	65.3	MARCH 25	j482sf
82	8415 2	3750792-12212149	d2	979952.27	979949.04	0.06	14.9	1.05	0.6	4 6	11.1	MARCH 25	j482sf
82	841526	3751000-12211800	d3	979950.25	979949.22	0.70	2.0	0.81	0.4	3 6	72.1	MARCH 25	j482sf
82	831519	3751115-12211477	d4	979950.80	979949.32	1.28	1.0	1.34	0.0	5 6	56.4	MARCH 24	j482sf
82	841347	3751276-12211136	d5	979951.65	979949.46	2.10	1.7	2.14	1.1	3 3	0.4	MARCH 25	j482sf
82	92 757	3750482-12215361	e1	979947.99	979948.77	-0.84	1.6	-0.80	1.1	5 6	1.0	APRIL 2	j482sf
82	92 818	3750758-12214813	e2	979948.23	979949.01	-0.85	1.5	-0.82	1.0	4 6	8.4	APRIL 2	j482sf
82	91 942	3751106-12214245	e3	979948.94	979949.32	-0.56	0.7	-0.50	-0.1	710	12.5	APRIL 1	j482sf
82	91165C	3751365-12213640	e4	979949.50	979949.54	-0.25	1.2	-0.18	0.2	4 6	10.7	APRIL 1	j482sf
82	8416 2	3751736-12213173	e5	979952.59	979949.86	-0.16	13.1	0.74	0.0	4 6	11.8	MARCH 25	j482sf
82	911719	3752068-12212586	e6	979950.59	979950.15	0.13	1.9	0.23	0.4	710	11.4	APRIL 1	j482sf
82	8413 4	3752289-12212034	e7	979950.92	979950.34	0.40	2.4	0.47	1.3	5 6	1.0	MARCH 25	j482sf
82	841235	3752644-12211455	e8	979950.43	979950.66	-0.30	2.0	-0.26	1.4	4 6	10.6	MARCH 25	j482sf
82	781025	3751432-12217527	f1	979950.32	979949.60	0.58	1.0	0.63	0.3	5 6	3.6	MARCH 19	j482sf
82	78111C	3751913-12216849	f2	979950.96	979950.02	0.66	1.2	0.75	-0.0	5 6	2.5	MARCH 19	j482sf
82	781148	3752245-12216134	f3	979951.65	979950.31	0.85	1.9	1.00	-0.2	3 6	85.3	MARCH 19	j482sf
82	781252	3752732-12215379	f4	979954.47	979950.73	0.36	14.5	1.40	-0.6	5 6	2.9	MARCH 19	j482sf
82	781328	3753127-12214499	f5	979952.43	979951.08	0.85	1.5	0.99	-0.7	4 6	12.2	MARCH 19	j482sf
82	841112	3753528-12213730	f6	979951.91	979951.43	0.24	2.4	0.33	1.1	4 6	1.9	MARCH 25	j482sf
82	841137	3753929-12213014	f7	979950.52	979951.78	-1.42	2.2	-1.35	1.3	5 6	1.3	MARCH 25	j482sf
82	8412 2	3754350-12212266	f8	979949.34	979952.14	-2.86	1.8	-2.82	1.3	4 6	2.1	MARCH 25	j482sf
82	78 921	3752737-12219075	g1	979951.41	979950.73	0.53	1.4	0.58	0.6	4 6	4.0	MARCH 19	j482sf
82	78 947	3753250-12218186	g2	979953.18	979951.18	1.74	1.7	1.82	0.5	4 6	3.6	MARCH 19	j482sf
82	781425	3753813-12217271	g3	979956.49	979951.68	1.94	12.0	2.82	-0.8	3 6	0.3	MARCH 19	j482sf
82	7815 C	3754330-12216112	g4	979954.87	979952.13	2.05	2.2	2.25	-0.8	5 6	7.0	MARCH 19	j482sf
82	841011	3755042-12214984	g5	979954.41	979952.75	1.35	2.2	1.45	0.7	5 6	1.3	MARCH 25	j482sf
82	841038	3755622-12213900	g6	979951.55	979953.26	-1.85	1.7	-1.80	0.9	5 6	1.3	MARCH 25	j482sf
82	77 931	3754552-12221506	h1	979952.76	979952.32	0.30	1.0	0.35	0.3	5 6	62.6	MARCH 18	j482sf
82	77 858	3755067-12220548	h2	979954.55	979952.77	1.59	1.5	1.66	0.5	5 6	58.1	MARCH 18	j482sf
82	84 8 2	3755672-12219401	h3	979956.87	979953.31	0.16	14.8	1.21	-0.4	5 6	8.0	MARCH 25	j482sf
82	781545	3756158-12218383	h4	979955.10	979953.73	0.39	3.7	0.68	-0.6	3 6	0.6	MARCH 19	j482sf
82	7711 8	3756803-12217341	h5	979953.50	979954.28	-1.27	2.0	-1.12	-0.2	3 6	0.9	MARCH 18	j482sf
82	771039	3757435-12216288	h6	979951.52	979954.84	-3.58	1.2	-3.50	-0.0	4 6	4.5	MARCH 18	j482sf

82 831129	3758026-12215152	h7	979949.39	979955.36	-6.05	2.0	-6.01	1.3	5 6	2.8	MARCH	24	j482sf
82 84 9 5	3755797-12224285	i1	979958.12	979953.41	4.48	1.2	4.56	0.1	5 6	5.4	MARCH	25	j482sf
82 84 828	3756409-12223145	i2	979955.25	979953.95	0.93	1.5	1.04	-0.2	4 6	4.0	MARCH	25	j482sf
82 83 8 7	3757039-12221966	i3	979957.68	979954.50	-0.46	16.5	0.67	0.1	4 6	3.8	MARCH	24	j482sf
82 83 831	3757668-12220880	i4	979954.52	979955.04	-1.25	3.7	-1.02	0.3	4 6	3.6	MARCH	24	j482sf
82 83 855	3758254-12219766	i5	979954.03	979955.55	-2.15	3.4	-1.95	0.5	5 6	5.4	MARCH	24	j482sf
82 83 915	3758932-12218621	i6	979952.30	979956.15	-4.34	3.0	-4.18	0.6	5 6	4.5	MARCH	24	j482sf
82 83 940	3759593-12217564	i7	979948.97	979956.73	-8.08	2.5	-7.97	0.8	5 6	4.6	MARCH	24	j482sf
82 8310 5	3760185-12216450	i8	979946.77	979957.24	-10.69	2.2	-10.61	1.0	5 6	3.4	MARCH	24	j482sf
82 831035	3760800-12215339	i9	979944.55	979957.78	-13.29	1.7	-13.26	1.2	5 6	3.3	MARCH	24	j482sf
82 951041	3757924-12229899	j1	979964.34	979955.27	8.86	2.2	8.94	1.1	2 3	0.0	APRIL	5	j482sf
82 92 957	3758499-12228872	j2	979966.75	979955.77	10.63	1.8	10.74	0.2	5 6	9.2	APRIL	2	j482sf
82 921029	3759137-12227719	j3	979961.66	979956.34	4.75	2.5	4.93	-0.1	5 6	8.0	APRIL	2	j482sf
82 95 925	3759670-12226565	j4	979962.38	979956.80	1.97	17.5	3.10	1.1	3 3	17.3	APRIL	5	j482sf
82 9211 4	3760294-12225663	j5	979959.86	979957.34	1.66	3.4	1.92	-0.4	5 6	8.3	APRIL	2	j482sf
82 921132	3760917-12224618	j6	979957.40	979957.88	-1.35	3.3	-1.09	-0.5	5 6	10.0	APRIL	2	j482sf
82 9212 6	3761550-12223516	j7	979955.62	979958.43	-3.83	3.7	-3.53	-0.7	5 6	8.0	APRIL	2	j482sf
82 921245	3762179-12222275	j8	979950.78	979958.98	-8.87	2.0	-8.68	-0.9	4 6	7.4	APRIL	2	j482sf
82 921423	3762859-12221340	j9	979945.98	979959.58	-14.24	1.7	-14.05	-1.0	510	7.6	APRIL	2	j482sf
82 96 754	3763374-12220085	j10	979942.27	979960.03	-18.19	2.2	-18.06	0.3	2 3	0.0	APRIL	6	j482sf
82 96 813	3764004-12218986	j11	979940.56	979960.59	-20.41	2.2	-20.29	0.4	3 6	8.4	APRIL	6	j482sf
82 96 841	3764613-12217900	j12	979939.60	979961.11	-21.84	2.2	-21.73	0.6	2 6	0.0	APRIL	6	j482sf
82 951131	3759048-12233118	k1	979969.06	979956.25	12.53	2.2	12.63	0.8	3 3	6.8	APRIL	5	j482sf
82 9216 4	3759732-12231983	k2	979968.13	979956.84	10.71	2.0	10.88	-0.5	3 3	20.8	APRIL	2	j482sf
82 921534	3760303-12230928	k3	979968.13	979957.35	9.93	3.0	10.18	-0.7	610	10.5	APRIL	2	j482sf
82 951436	3760863-12229784	k4	979964.76	979957.83	5.94	3.7	6.24	-0.6	4 6	9.3	APRIL	5	j482sf
82 9515 3	3761477-12228734	k5	979965.02	979958.37	3.64	12.6	4.56	-0.8	5 6	7.8	APRIL	5	j482sf
82 89 847	3762024-12227729	k6	979963.16	979958.85	3.32	3.5	3.61	-0.8	5 6	8.8	MARCH	30	j482sf
82 89 912	3762535-12226807	k7	979960.53	979959.31	0.41	2.6	0.65	-0.9	5 6	9.1	MARCH	30	j482sf
82 89 936	3763189-12225712	k8	979956.84	979959.87	-4.38	4.9	-3.98	-1.0	4 6	7.9	MARCH	30	j482sf
82 89 959	3763785-12224547	k9	979951.48	979960.40	-9.78	2.6	-9.53	-1.1	4 6	7.4	MARCH	30	j482sf
82 891030	3764381-12223470	k10	979947.26	979960.91	-14.40	2.1	-14.18	-1.1	4 6	8.4	MARCH	30	j482sf
82 8911 6	3765011-12222336	k11	979943.93	979961.46	-18.21	1.8	-18.01	-1.0	4 6	7.2	MARCH	30	j482sf
82 96 925	3765602-12221214	k12	979941.80	979961.98	-20.68	3.3	-20.51	0.9	5 6	5.9	APRIL	6	j482sf
82 96 951	3766230-12220120	k13	979940.50	979962.54	-22.38	2.7	-22.26	1.0	4 6	5.0	APRIL	6	j482sf
82 961020	3766843-12218997	k14	979940.79	979963.06	-22.53	2.5	-22.44	1.1	4 6	4.7	APRIL	6	j482sf
82 951221	3761334-12234027	l1	979969.85	979958.24	10.90	3.7	11.12	0.4	3 3	6.7	APRIL	5	j482sf
82 951252	3762021-12232901	l2	979968.42	979958.85	8.56	4.7	8.87	0.1	710	13.2	APRIL	5	j482sf
82 951314	3762573-12231809	l3	979966.73	979959.33	6.45	4.2	6.74	-0.0	4 6	9.6	APRIL	5	j482sf
82 951341	3763267-12230782	l4	979966.85	979959.95	4.41	10.9	5.18	-0.3	6 6	11.9	APRIL	5	j482sf
82 9514 1	3763860-12229577	l5	979965.47	979960.46	3.48	6.4	3.95	-0.4	5 6	8.8	APRIL	5	j482sf
82 961357	3764252-12228762	l6	979962.71	979960.80	1.51	1.8	1.63	0.0	4 6	5.7	APRIL	6	j482sf
82 961428	3764846-12227738	l7	979959.36	979961.31	-3.27	5.7	-2.87	-0.2	4 6	5.8	APRIL	6	j482sf
82 961332	3765426-12226712	l8	979954.85	979961.82	-8.15	5.6	-7.78	0.3	4 6	6.0	APRIL	6	j482sf
82 9613 5	3766059-12225601	l9	979951.12	979962.38	-12.33	5.4	-11.99	0.5	5 6	9.7	APRIL	6	j482sf
82 961244	3766678-12224463	l10	979947.42	979962.92	-16.35	4.6	-16.08	0.6	5 6	7.8	APRIL	6	j482sf
82 961224	3767303-12223366	l11	979945.16	979963.47	-18.92	3.7	-18.72	0.8	4 6	5.3	APRIL	6	j482sf
82 9612 6	3767917-12222278	l12	979944.10	979964.01	-20.43	3.4	-20.26	0.9	5 6	9.1	APRIL	6	j482sf
82 961145	3768582-12221082	l13	979943.97	979964.59	-20.91	2.5	-20.81	1.0	4 6	3.8	APRIL	6	j482sf
82 97 859	3763443-12235684	m1	979972.32	979960.09	11.49	3.7	11.73	0.3	3 6	7.2	APRIL	7	j482sf
82 97 924	3764087-12234549	m2	979970.71	979960.66	8.91	5.7	9.27	0.5	4 6	13.0	APRIL	7	j482sf
82 97 948	3764739-12233445	m3	979969.78	979961.23	7.11	7.2	7.57	0.6	4 6	4.3	APRIL	7	j482sf
82 971017	3765308-12232324	m4	979970.03	979961.72	6.27	10.1	6.91	0.8	4 6	3.8	APRIL	7	j482sf

82 971036	3765951-12231205	m5	979968.63	979962.29	4.49	9.4	5.08	0.9	4 6	8.2	APRIL 7	j482sf
82 9711 3	3766581-12230076	m6	979965.48	979962.84	1.95	4.2	2.18	1.0	5 6	7.7	APRIL 7	j482sf
82 971128	3767019-12229324	m7	979963.83	979963.22	-1.05	8.6	-0.52	1.0	4 6	5.6	APRIL 7	j482sf
82 971152	3767307-12228057	m8	979958.13	979963.47	-6.77	7.6	-6.31	1.0	4 6	7.1	APRIL 7	j482sf
82 971222	3768326-12227014	m9	979955.65	979964.36	-9.94	6.7	-9.55	0.9	3 3	1.5	APRIL 7	j482sf
82 971245	3768829-12226129	m10	979954.21	979964.81	-11.63	5.7	-11.30	0.8	4 6	3.5	APRIL 7	j482sf
82 97131C	3769331-12225166	m11	979952.62	979965.24	-13.44	4.5	-13.18	0.7	5 6	2.9	APRIL 7	j482sf
82 971335	3769969-12224070	m12	979951.17	979965.80	-15.18	3.1	-15.00	0.5	5 6	3.2	APRIL 7	j482sf
82 98 828	3765120-12237490	n1	979976.63	979961.56	14.57	2.0	14.72	-0.2	4 6	9.3	APRIL 8	j482sf
82 98 855	3765735-12236369	n2	979974.12	979962.10	10.85	5.2	11.21	-0.1	4 6	9.6	APRIL 8	j482sf
82 98 918	3766342-12235262	n3	979973.18	979962.62	9.10	6.7	9.55	0.1	4 6	7.1	APRIL 8	j482sf
82 98 939	3766949-12234137	n4	979974.03	979963.16	8.97	8.8	9.56	0.2	4 6	7.8	APRIL 8	j482sf
82 98 959	3767480-12233246	n5	979973.70	979963.63	8.14	9.1	8.75	0.4	5 6	10.7	APRIL 8	j482sf
82 981019	3768084-12232116	n6	979972.01	979964.15	5.96	9.1	6.55	0.5	4 6	8.3	APRIL 8	j482sf
82 981038	3768555-12231294	n7	979969.99	979964.56	4.22	6.1	4.60	0.6	5 6	6.7	APRIL 8	j482sf
82 981059	3769045-12230381	n8	979967.77	979965.00	0.56	10.8	1.26	0.7	4 6	9.7	APRIL 8	j482sf
82 981121	3769522-12229211	n9	979964.60	979965.40	-2.29	7.7	-1.82	0.8	5 6	8.8	APRIL 8	j482sf
82 981141	3770350-12228167	n10	979962.49	979966.13	-5.30	8.5	-4.78	0.9	5 6	8.5	APRIL 8	j482sf
82 9812 1	3770891-12227081	n11	979960.01	979966.61	-7.55	5.4	-7.24	1.0	4 6	6.4	APRIL 8	j482sf
82 981223	3771546-12225952	n12	979959.10	979967.18	-8.71	4.0	-8.50	0.9	4 6	5.1	APRIL 8	j482sf
82 9910 1	3768092-12237454	o1	979975.65	979964.15	11.03	2.2	11.18	0.1	3 6	9.1	APRIL 9	j482sf
82 991036	3763636-12236943	o2	979975.37	979964.63	10.21	2.7	10.38	0.3	3 6	9.3	APRIL 9	j482sf
82 991053	3768729-12236026	o3	979976.35	979964.72	10.04	7.7	10.54	0.4	3 6	6.5	APRIL 9	j482sf
82 991110	3769472-12235484	o4	979977.29	979965.36	9.93	9.6	10.56	0.5	5 6	9.9	APRIL 9	j482sf
82 991152	3769898-12234703	o5	979976.70	979965.74	8.69	11.1	9.40	0.7	5 6	10.6	APRIL 9	j482sf
821061012	3770566-12233697	o6	979977.11	979966.32	8.20	11.2	8.99	-0.4	5 6	9.7	APRIL 16	j482sf
821061042	3771224-12232583	o7	979972.72	979966.90	3.22	11.1	4.02	-0.5	5 6	5.3	APRIL 16	j482sf
8210611 9	3771857-12231425	o8	979971.72	979967.46	1.89	10.1	2.62	-0.5	5 6	7.3	APRIL 16	j482sf
821061134	3772421-12230366	o9	979970.92	979967.95	0.98	8.3	1.59	-0.5	5 6	8.0	APRIL 16	j482sf
82 981338	3773020-12229226	o10	979968.96	979968.48	-0.50	5.3	-0.19	0.7	5 6	6.1	APRIL 8	j482sf
82 981317	3773751-12228045	o11	979969.42	979969.12	-1.90	10.9	-1.21	0.8	5 6	7.2	APRIL 8	j482sf
82 981252	3774362-12226891	o12	979967.18	979969.64	-2.90	3.0	-2.75	0.9	5 6	5.3	APRIL 8	j482sf
821061225	3775003-12225780	o13	979966.30	979970.21	-4.31	1.2	-4.19	-0.5	510	18.3	APRIL 16	j482sf
8210618 5	3773014-12235168	p1	979979.11	979968.46	5.42	24.0	7.05	0.4	610	10.4	APRIL 16	j482sf
82106164C	3773487-12234230	p2	979975.90	979968.88	3.33	16.8	4.47	0.1	4 6	8.7	APRIL 16	j482sf
821061610	3773973-12233286	p3	979976.00	979969.31	3.36	15.1	4.39	0.0	4 6	7.0	APRIL 16	j482sf
821061537	3774548-12232327	p4	979974.73	979969.80	2.71	9.9	3.39	-0.1	5 6	5.8	APRIL 16	j482sf
8210615 3	3775081-12231417	p5	979973.84	979970.27	2.25	5.7	2.66	-0.2	5 6	5.8	APRIL 16	j482sf
821061311	3775700-12230331	p6	979972.42	979970.82	0.66	3.6	0.95	-0.5	4 6	4.1	APRIL 16	j482sf
821061339	3776437-12229033	p7	979970.74	979971.46	-1.22	1.7	-1.07	-0.5	5 6	6.5	APRIL 16	j482sf
82 991233	3776878-12237616	q1	979982.60	979971.85	8.00	13.3	8.86	0.8	4 6	6.1	APRIL 9	j482sf
82 991253	3777143-12236837	q2	979982.35	979972.07	6.82	16.5	7.90	0.8	4 6	13.2	APRIL 9	j482sf
82 991313	3777388-12235958	q3	979982.22	979972.29	5.59	20.5	6.94	0.8	5 6	38.6	APRIL 9	j482sf
82 991334	3777644-12235175	q4	979981.52	979972.52	5.13	18.3	6.34	0.7	4 6	8.1	APRIL 9	j482sf
82 991353	3777951-12234319	q5	979980.30	979972.79	4.41	14.8	5.38	0.7	5 6	6.5	APRIL 9	j482sf
821061416	3778202-12233523	q6	979978.45	979973.00	3.28	9.3	3.95	-0.4	5 6	6.2	APRIL 16	j482sf
821091034	3782609-12233280	r1	979975.94	979976.86	-1.59	3.2	-1.38	0.2	1 1	0.0	APRIL 19	j482sf
8210911 9	3783015-12232017	r2	979975.57	979977.23	-2.09	1.9	-1.95	0.0	1 1	0.0	APRIL 19	j482sf
821091138	3783463-12230775	r3	979975.32	979977.62	-2.61	1.2	-2.51	-0.1	3 3	32.8	APRIL 19	j482sf
8210916 3	3783043-12240227	s1	979985.94	979977.24	4.49	18.5	5.78	-0.4	5 6	12.8	APRIL 19	j482sf
821091533	3783422-12238949	s2	979982.81	979977.57	2.99	9.5	3.68	-0.5	5 6	14.9	APRIL 19	j482sf
821091455	3783823-12237707	s3	979981.14	979977.92	1.22	8.4	1.83	-0.5	4 6	18.0	APRIL 19	j482sf
821091424	3784241-12236385	s4	979980.18	979978.29	0.16	7.1	0.69	-0.5	5 6	21.6	APRIL 19	j482sf

821091354	3784589-12235123	s5	979979.71	979978.59	0.21	3.4	0.48	-0.5	2	3	0.0	APRIL 19	j482sf
821091327	3784980-12233885	s6	979979.40	979978.94	-0.32	2.9	-0.08	-0.5	2	3	0.0	APRIL 19	j482sf
8210913 1	3785339-12232498	s7	979979.17	979979.26	-0.75	2.4	-0.55	-0.5	2	3	0.0	APRIL 19	j482sf
821091232	3785679-12231138	s8	979978.32	979979.55	-1.76	2.0	-1.60	-0.4	3	3	15.3	APRIL 19	j482sf
82110 8 5	3785422-12240265	t1	979987.85	979979.34	1.24	33.5	3.50	0.6	3	3	5.4	APRIL 20	j482sf
82110 841	3785779-12238947	t2	979983.18	979979.64	1.64	9.3	2.24	0.7	4	6	18.3	APRIL 20	j482sf
82110 9 9	3786193-12237703	t3	979982.53	979980.01	1.45	5.7	1.79	0.7	4	6	15.8	APRIL 20	j482sf
82110 932	3786565-12236409	t4	979981.88	979980.33	0.91	3.7	1.11	0.7	5	6	16.9	APRIL 20	j482sf
82110 956	3786969-12235142	t5	979982.12	979980.69	0.79	3.6	0.99	0.6	4	6	18.3	APRIL 20	j482sf
821101021	3787325-12233835	t6	979982.09	979981.00	0.46	3.5	0.66	0.6	4	6	21.2	APRIL 20	j482sf
821101047	3787723-12232549	t7	979980.74	979981.35	-1.09	2.7	-0.93	0.4	4	6	21.0	APRIL 20	j482sf
821101254	3788103-12239116	u1	979984.65	979981.68	1.71	5.4	2.10	-0.3	4	6	13.5	APRIL 20	j482sf
82110123C	3788477-12237800	u2	979985.34	979982.00	2.82	2.2	2.98	-0.1	4	6	13.4	APRIL 20	j482sf
8211012 6	3788852-12236509	u3	979984.96	979982.34	2.14	2.2	2.29	-0.0	4	6	17.9	APRIL 20	j482sf
821101141	3789194-12235244	u4	979984.26	979982.64	1.13	2.4	1.28	0.1	3	5	16.4	APRIL 20	j482sf
82110112C	3789551-12234037	u5	979982.59	979982.95	-0.81	2.4	-0.67	0.3	3	6	13.2	APRIL 20	j482sf
821101453	3789246-12243344	v1	979989.92	979982.68	2.72	19.7	4.11	-0.5	3	3	9.8	APRIL 20	j482sf
821101423	3789617-12242261	v2	979987.87	979983.00	1.89	12.8	2.80	-0.5	3	6	12.1	APRIL 20	j482sf
821101354	3789992-12241077	v3	979987.07	979983.34	2.30	5.9	2.74	-0.4	3	6	13.8	APRIL 20	j482sf
82110133C	3790357-12239801	v4	979988.03	979983.66	2.95	5.9	3.39	-0.4	3	6	13.6	APRIL 20	j482sf
8211210 4	3791379-12245564	w1	979990.43	979984.55	4.08	8.9	4.65	0.6	2	3	0.0	APRIL 22	j482sf
821121028	3791788-12244275	w2	979990.72	979984.91	3.20	12.5	4.02	0.7	2	3	0.0	APRIL 22	j482sf
82112105C	3792155-12242965	w3	979989.84	979985.23	3.06	7.9	3.55	0.7	2	3	0.0	APRIL 22	j482sf
82112111C	3792427-12241922	w4	979990.84	979985.47	2.39	14.3	3.33	0.7	2	3	0.0	APRIL 22	j482sf
821121235	3794363-12246397	x1	979992.35	979987.17	4.12	5.4	4.46	0.5	1	6	0.0	APRIL 22	j482sf
821121218	3794411-12245140	x2	979993.68	979987.21	3.02	16.3	4.09	0.6	2	6	0.0	APRIL 22	j482sf
821121159	3794514-12243741	x3	979994.11	979987.30	2.88	18.5	4.10	0.7	1	3	0.0	APRIL 22	j482sf
821121125	3794302-12243110	x4	979993.17	979987.11	2.53	16.8	3.63	0.7	2	3	0.0	APRIL 22	j482sf
821121321	3796992-12246556	y1	979993.36	979989.47	3.61	1.7	3.70	0.3	2	3	0.0	APRIL 22	j482sf
821121348	3796836-12245224	y2	979991.84	979989.34	1.99	2.4	2.15	0.1	2	3	0.0	APRIL 22	j482sf
821121436	3796696-12243936	y3	979995.64	979989.21	1.06	23.9	2.72	-0.2	2	3	0.0	APRIL 22	j482sf
821161251	3796704-12242443	z1	979991.50	979989.22	1.76	2.2	1.92	-0.1	2	3	0.0	APRIL 26	j482sf
821161318	3797382-12241681	z2	979989.48	979989.82	-0.53	1.0	-0.47	0.1	1	1	0.0	APRIL 26	j482sf
821161339	3798056-12240846	z3	979989.20	979990.40	-1.43	1.3	-1.36	0.2	2	3	0.0	APRIL 26	j482sf
8211614 5	3798854-12239968	z4	979989.20	979991.10	-2.20	1.7	-2.11	0.3	3	5	7.8	APRIL 26	j482sf
821161423	3799773-12239017	z5	979988.23	979991.91	-4.29	3.2	-4.10	0.4	5	6	2.3	APRIL 26	j482sf
821161442	3800295-12238382	z6	979988.23	979992.37	-4.61	2.7	-4.46	0.5	4	6	1.4	APRIL 26	j482sf
82117103C	3800813-12237781	z7	979988.43	979992.82	-4.96	1.2	-4.80	-1.1	2	3	0.0	APRIL 27	j482sf
8211711 C	3801350-12237211	z8	979983.53	979993.30	-10.48	2.0	-10.28	-1.1	2	3	0.0	APRIL 27	j482sf
821171126	3801613-12236344	z9	979974.79	979993.53	-19.49	2.2	-19.27	-1.0	3	3	2.9	APRIL 27	j482sf
821171158	3801932-12235400	z10	979966.92	979993.81	-27.66	2.4	-27.43	-0.9	3	3	7.9	APRIL 27	j482sf
821171222	3802182-12234616	z11	979963.31	979994.03	-31.45	2.4	-31.24	-0.7	2	3	0.0	APRIL 27	j482sf
821171241	3802437-12233756	z12	979961.21	979994.24	-33.75	2.5	-33.53	-0.6	4	6	4.7	APRIL 27	j482sf
8211713 5	3802718-12232948	z13	979959.93	979994.49	-35.24	2.4	-35.04	-0.5	4	6	4.6	APRIL 27	j482sf
821171335	3803126-12231651	z14	979960.27	979994.86	-35.22	2.5	-35.03	-0.3	4	6	4.8	APRIL 27	j482sf
821171357	3803543-12230366	z15	979962.02	979995.22	-33.80	2.5	-33.62	-0.2	3	6	2.5	APRIL 27	j482sf
821171415	3803812-12229516	z16	979963.23	979995.45	-32.85	2.7	-32.66	-0.1	4	6	4.5	APRIL 27	j482sf
821171436	3804057-12228681	z17	979963.70	979995.67	-32.62	3.0	-32.42	0.0	2	6	0.0	APRIL 27	j482sf
821171454	3804341-12227827	z18	979965.22	979995.92	-31.35	3.1	-31.15	0.1	3	6	9.2	APRIL 27	j482sf
82117151C	3804616-12226980	z19	979967.50	979996.17	-29.35	3.3	-29.13	0.2	4	6	10.7	APRIL 27	j482sf
821301538	3800079-12245412	aa1	979995.17	979992.18	2.41	3.3	2.60	0.5	5	6	3.0	MAY 10	j482sf
82120 945	3800602-12244506	aa2	979994.31	979992.64	0.78	4.0	1.05	-0.1	4	6	0.8	APRIL 30	j482sf
8212010 8	3801146-12243579	aa3	979993.21	979993.12	-0.79	3.7	-0.52	-0.2	5	6	1.6	APRIL 30	j482sf

821201028	3801757-12242510	aa4	979991.82	979993.65	-3.01	4.9	-2.65	-0.4	5 6	2.0	APRIL	30	j482sf
821201051	3802363-12241352	aa5	979990.56	979994.19	-4.79	4.7	-4.44	-0.5	4 6	3.0	APRIL	30	j482sf
821201113	3802809-12240574	aa6	979989.47	979994.58	-6.15	4.0	-5.83	-0.6	5 6	4.7	APRIL	30	j482sf
82120114C	3803227-12239832	aa7	979988.97	979994.94	-6.98	3.7	-6.68	-0.7	5 6	5.8	APRIL	30	j482sf
8212012 4	3803658-12239102	aa8	979984.35	979995.32	-11.94	3.4	-11.65	-0.8	5 6	6.3	APRIL	30	j432sf
821201228	3803934-12238345	aa9	979976.95	979995.57	-19.61	3.5	-19.31	-0.8	4 6	4.5	APRIL	30	j482sf
821201252	3804208-12237363	aa10	979968.69	979995.80	-28.21	3.9	-27.88	-0.9	5 6	10.2	APRIL	30	j482sf
821201322	3804469-12236518	aa11	979964.15	979996.03	-33.22	5.0	-32.82	-0.9	4 6	8.2	APRIL	30	j482sf
821201349	3804737-12235653	aa12	979962.03	979996.27	-35.68	5.4	-35.24	-0.9	5 6	13.0	APRIL	30	j482sf
821201414	3804984-12234800	aa13	979961.05	979996.49	-36.83	5.3	-36.41	-0.8	5 6	10.6	APRIL	30	j482sf
821201438	3805415-12233560	aa14	979960.66	979996.86	-37.45	4.7	-37.07	-0.8	4 6	7.1	APRIL	30	j482sf
821201512	3805913-12232254	aa15	979961.23	979997.30	-37.03	3.5	-36.74	-0.6	4 6	6.1	APRIL	30	j482sf
82120154C	3306204-12230943	aa16	979962.21	979997.55	-36.03	2.5	-35.82	-0.5	5 6	13.3	APRIL	30	j482sf
821201559	3306610-12229716	aa17	979964.43	979997.91	-33.87	1.3	-33.75	-0.4	4 6	18.0	APRIL	30	j482sf
8213319 2	3306916-12228916	aa18	979965.75	979998.17	-32.66	1.6	-32.58	0.5	3 6	18.3	MAY	13	j482sf
821231052	3307335-12227747	aa19	979971.12	979998.55	-27.45	0.7	-27.44	0.5	5 6	4.1	MAY	3	j482sf
82134 422	3803287-12249240	bb1	979998.94	979995.00	3.87	1.0	3.90	0.6	4 6	6.7	MAY	14	j482sf
82134 348	3803698-12247910	bb2	979998.31	979995.35	2.75	1.7	2.83	0.6	3 6	5.4	MAY	14	j482sf
82131 853	3804103-12246648	bb3	979997.36	979995.71	1.18	1.0	1.31	-0.9	410	4.0	MAY	11	j482sf
82131 914	3804519-12245407	bb4	979996.19	979996.08	-0.39	1.3	-0.25	-0.8	610	8.6	MAY	11	j482sf
82131 941	3804936-12244122	bb5	979995.73	979996.44	-1.29	1.6	-1.12	-0.8	4 6	13.1	MAY	11	j482sf
82130 835	3805382-12242911	bb6	979995.58	979996.84	-1.91	1.9	-1.72	-0.9	4 6	9.0	MAY	10	j482sf
82130 9 4	3805617-12242098	bb7	979992.63	979997.04	-5.09	2.1	-4.89	-0.8	5 6	8.9	MAY	10	j482sf
82130 93C	3805908-12241211	bb8	979986.61	979997.30	-11.35	2.1	-11.16	-0.7	4 6	8.2	MAY	10	j482sf
82130 952	3806174-12240378	bb9	979978.92	979997.53	-19.27	2.2	-19.08	-0.7	4 6	7.8	MAY	10	j482sf
821301021	3806450-12239538	bb10	979970.53	979997.77	-27.82	2.0	-27.65	-0.5	4 6	8.6	MAY	10	j482sf
821301039	3806720-12238675	bb11	979965.54	979998.01	-33.04	2.0	-32.87	-0.4	510	8.8	MAY	10	j482sf
821301059	3806970-12237820	bb12	979963.09	979998.23	-35.67	2.0	-35.51	-0.3	3 6	0.0	MAY	10	j482sf
821301130	3807258-12236978	bb13	979961.68	979998.48	-37.28	2.0	-37.13	-0.2	4 6	2.7	MAY	10	j482sf
821301148	3307480-12236142	bb14	979960.95	979998.67	-38.17	2.0	-38.03	-0.1	5 6	5.1	MAY	10	j482sf
82124 933	3808622-12236701	bb15	979961.90	979999.67	-38.17	2.7	-38.04	0.7	3 6	11.3	MAY	4	j462sf
821241019	3308304-12233574	bb16	979961.43	979999.40	-38.36	2.7	-38.23	0.8	4 6	4.4	MAY	4	j482sf
821241046	3808724-12232255	bb17	979961.84	979999.76	-38.26	2.4	-38.15	0.8	5 6	9.9	MAY	4	j482sf
8212411 9	3809086-12231013	bb18	979963.46	980000.08	-36.91	2.2	-36.81	0.7	3 6	0.3	MAY	4	j482sf
821241133	3809486-12229725	bb19	979967.21	980000.43	-33.28	1.0	-33.25	0.6	3 6	0.3	MAY	4	j482sf
821311253	3806104-12247698	cc1	979998.78	979997.46	1.12	0.9	1.18	0.0	4 6	5.4	MAY	11	j482sf
821311226	3806526-12246451	cc2	979998.94	979997.84	0.82	1.1	0.91	-0.1	5 6	4.4	MAY	11	j482sf
821311154	3806930-12245173	cc3	979999.95	979998.19	1.44	1.2	1.53	-0.3	5 6	5.3	MAY	11	j482sf
821311143	3807354-12243948	cc4	979995.74	979998.57	-3.19	1.2	-3.08	-0.3	710	8.2	MAY	11	j482sf
821311115	3807601-12243029	cc5	979990.92	979998.79	-8.35	1.6	-8.21	-0.5	4 6	43.2	MAY	11	j482sf
821311044	3807860-12242235	cc6	979984.32	979999.00	-15.12	1.3	-15.00	-0.6	3 6	38.2	MAY	11	j482sf
821311019	3808166-12241372	cc7	979975.10	979999.28	-24.64	1.2	-24.51	-0.7	3 6	12.9	MAY	11	j482sf
821301220	3808436-12240520	cc8	979969.62	979999.51	-30.26	1.7	-30.14	0.1	3 6	9.6	MAY	10	j462sf
821301239	3808693-12239660	cc9	979966.35	979999.75	-33.79	2.0	-33.67	0.2	4 6	4.5	MAY	10	j482sf
8213013 7	3809017-12238817	cc10	979964.58	980000.02	-35.80	1.9	-35.69	0.3	4 6	4.0	MAY	10	j482sf
821301329	3309264-12237979	cc11	979963.54	980000.24	-37.05	2.0	-36.94	0.4	5 6	5.4	MAY	10	j482sf
821301352	3809670-12236736	cc12	979962.75	980000.59	-38.16	2.0	-38.05	0.4	4 6	3.9	MAY	10	j482sf
821321053	3810057-12235397	cc13	979962.62	980000.94	-38.72	0.9	-38.60	-0.7	4 6	4.6	MAY	12	j482sf
8213321 7	3810477-12234177	cc14	979963.19	980001.30	-38.46	1.9	-38.35	0.3	4 6	5.0	MAY	13	j482sf
821332026	3810864-12232935	cc15	979964.02	980001.64	-37.85	1.5	-37.77	0.4	5 6	7.4	MAY	13	j482sf
8212412 6	3311176-12231694	cc16	979964.39	980001.92	-37.50	0.5	-37.50	0.5	3 6	1.2	MAY	4	j482sf
821311328	3808529-12247507	dd1	979999.51	979999.60	-0.24	0.9	-0.19	0.2	4 6	11.0	MAY	11	j482sf
82131142C	3808997-12246178	dd2	979997.55	980000.01	-2.66	1.4	-2.59	0.4	5 6	5.1	MAY	11	j482sf

821311446	3809362-12244914	dd3	979994.47	980000.33	-6.09	1.5	-6.01	0.4	3 6	0.9	MAY	11	j482sf
821311517	3809632-12244047	dd4	979989.13	980000.56	-11.68	1.7	-11.60	0.5	3 6	0.5	MAY	11	j482sf
8213322 4	3809867-12243254	dd5	979983.11	980000.77	-17.92	1.5	-17.83	0.3	3 6	6.8	MAY	13	j482sf
821332239	3810163-12242357	dd6	979976.58	980001.03	-24.71	1.5	-24.62	0.3	3 6	6.5	MAY	13	j482sf
8213323 2	3810390-12241563	dd7	979972.56	980001.23	-28.93	1.5	-28.85	0.3	4 6	4.8	MAY	13	j482sf
821332337	3810686-12240722	dd8	979969.90	980001.49	-31.83	1.5	-31.75	0.3	5 6	5.0	MAY	13	j482sf
821332351	3810980-12239861	dd9	979968.37	980001.74	-33.61	1.5	-33.53	0.4	4 6	3.5	MAY	13	j482sf
82134 022	3811264-12239044	dd10	979967.48	980002.00	-34.74	1.4	-34.67	0.4	4 6	5.8	MAY	14	j482sf
82134 237	3811660-12237774	dd11	979966.87	980002.34	-35.63	1.5	-35.57	0.6	4 6	3.2	MAY	14	j482sf
82134 133	3812072-12236507	dd12	979965.82	980002.70	-37.01	1.2	-36.96	0.5	4 6	4.1	MAY	14	j482sf
82134 2 5	3812450-12235207	dd13	979965.42	980003.04	-37.63	0.7	-37.62	0.6	4 6	5.0	MAY	14	j482sf
821371059	3787607-12248362	ee1	979989.63	979981.24	7.95	1.5	8.08	-0.4	4 6	15.7	MAY	17	j482sf
821371027	3786358-12247198	ee2	979988.76	979980.15	7.98	2.5	8.17	-0.3	4 5	11.2	MAY	17	j482sf
82137 950	3784570-12244963	ee3	979987.58	979978.58	5.12	17.3	6.31	-0.1	4 5	9.8	MAY	17	j482sf
82137 917	3782059-12244062	ee4	979988.12	979976.38	6.87	21.9	8.37	0.0	5 6	12.0	MAY	17	j482sf
82 82 846	3755288-12219561	1t02	979956.45	979952.97	0.96	12.2	1.75	0.7	5 6	28.1	MARCH	23	j482sf
82 7615 7	3751375-12213361	1t14	979950.42	979949.55	-0.01	4.0	0.26	0.0	3 6	38.4	MARCH	17	j482sf
82 761239	3751758-12220532	1t15	979953.06	979949.89	1.04	9.1	1.70	-0.4	4 6	10.5	MARCH	17	j482sf
82 7614 3	3758312-12225133	tw18	979960.49	979955.61	1.54	14.8	2.57	-0.2	5 6	31.4	MARCH	17	j482sf

REMEASURED STATIONS

82125 926	3805626-12242083	bb7	979992.40	979997.05	-5.19	3.0	-5.01	0.5	5 6	10.6	MAY	5	j482sf
82125 957	3805326-12242906	bb6	979995.52	979996.79	-1.77	3.0	-1.61	0.6	5 6	7.9	MAY	5	j482sf
821251037	3804926-12244136	bb5	979995.58	979996.43	-1.36	3.1	-1.20	0.7	4 6	6.0	MAY	5	j482sf
8212511 7	3804514-12245453	bb4	979995.93	979996.08	-0.57	2.7	-0.43	0.7	5 6	4.9	MAY	5	j482sf
821251138	3804106-12246646	bb3	979997.01	979995.71	0.93	2.5	1.05	0.7	4 6	4.0	MAY	5	j482sf
8212512 2	3803702-12247989	bb2	979997.80	979995.36	2.22	1.7	2.29	0.6	3 6	3.8	MAY	5	j482sf
821251225	3803299-12249275	bb1	979998.54	979995.00	3.46	1.0	3.49	0.5	4 6	4.5	MAY	5	j482sf
821251257	3806132-12247748	cc1	979998.39	979997.49	0.63	1.7	0.72	0.4	4 6	3.8	MAY	5	j482sf
821251325	3808539-12247479	dd1	979999.28	979999.60	-0.58	1.5	-0.50	0.3	4 6	3.5	MAY	5	j482sf
821231020	3806934-12228904	aa18	979965.75	979998.19	-32.69	1.9	-32.60	0.6	2 3	0.0	MAY	3	j482sf
821231134	3809087-12231013	bb18	979963.48	980000.08	-37.00	2.1	-36.87	0.3	3 6	0.3	MAY	3	j482sf
8212312 1	3808727-12232257	bb17	979961.79	979999.78	-38.43	2.1	-38.29	0.1	5 6	8.3	MAY	3	j482sf

NAVIGATIONAL MARKERS

82	0 0 C	3805300-12232966	1t01	510	0.4	j482sf
82	0 0 C	3805302-12232966	1t01	510	0.6	j482sf
82	0 0 0	3805316-12232960	1t01	5 6	16.5	j482sf
82	0 0 C	3755281-12219581	1t02	3 6	3.7	j482sf
82	0 0 0	3755286-12219581	1t02	3 6	1.7	j482sf
82	0 0 C	3755281-12219581	1t02	3 6	1.1	j482sf
82	0 0 C	3781092-12240888	dock	5 6	23.1	j482sf
82	0 0 C	3781095-12240886	dock	5 6	23.3	j482sf
82	0 0 0	3781091-12240861	dock	5 6	22.1	j482sf
82	0 0 C	3804910-12242103	1t02	510	7.5	j482sf
82	0 0 0	3804911-12242102	1t02	4 6	7.6	j482sf
82	0 0 C	3804911-12242101	1t02	510	8.1	j482sf
82	0 0 0	3750478-12221811	marf	4 6	3.5	j482sf
82	0 0 C	3750468-12221791	marf	715	62.3	j482sf
82	0 0 C	3750457-12221754	marf	3 6	84.2	j482sf

TABLE 4
Navigational Errors at Fixed Reference Points

Station	N	SD(y)	SD(x)	SD(y,x)	var(max)/2
1t01	3	9.7 m	3.0 m	10.1 m	8.3 m
1t02	5	4.0	9.1	9.9	14.0
dock	3	2.3	13.1	13.3	11.6
1t02	3	0.6	0.6	0.9	4.1
marf	3	11.6	25.3	27.8	31.1

SD - standard deviation of N fixes, in meters

SD(y,x) - SQRT [SD(y)**2 + SD(x)**2]

var(max) - maximum variance of N fixes, in meters

TABLE 5
Free-Air Anomaly Errors at Reoccupied Stations

Station	Position dy(m)	dx(m)	Height dh(ft)	Free-air anomalies dfaa(mG)	dfaa*(mG)
bb7	-10.0	+12.2	+0.40	+0.12	+0.11
bb6	+62.2	+ 4.4	+0.43	-0.11	-0.19
bb5	+11.2	-56.0	0.00	+0.14	-0.03
bb4	+ 5.6	-40.06	+0.06	+0.24	+0.01
bb3	- 3.4	+ 1.8	+0.09	+0.31	+0.01
bb2	- 4.4	-69.2	-0.03	+0.54	+0.18
bb1	-13.4	-30.6	+0.06	+0.41	0.00
cc1	-31.0	-43.8	-0.43	+0.54	+0.06
dd1	-11.2	+24.6	-0.52	+0.39	-0.15
aa18	-40.0	+21.0	-0.06	+0.03	0.00
bb18	- 2.2	0.0	+0.37	+0.10	-0.02
bb17	- 6.6	- 3.6	+0.34	+0.17	+0.01

Columns represent difference between accepted and remeasured values; dfaa* is free-air anomaly difference after presumed drift correction.

Gradient diagram in vicinity of stations bb7 - dd1

```
                          ^cc
                           |
              ^cc4         |  -0.0030N
               |           |
               |           |
          -0.0017E         |            -0.0026E
   cc1 ------------->  bb8 ------------->  aa15
               |           |
               |bb5        |
               |           |
  -0.0005N     |           |aa5
               |
               |aa2

                                      all gradients in mGal/meter
                                      N - north gradient
                                      E - east gradient
```

APPENDIX A

```
c       PROGRAM SFBAY_GRAVCALC
c
c       This program calculates free-air and Bouguer corrections for gravity
c       measurements taken on the bay floor of San Francisco Bay during a
c       joint program for the Defense Mapping Agency and the USGS.
c
c       Theoretical gravity is calculated from the 1967 international gravity
c       formula:
c
c       g = 978031.85*(1+0.0053024*sin(lat)**2 - 0.00000587*sin(2*lat)**2)
c
c       Input to the program consists of observed gravity, position (latitude,
c       longitude), water depth from pressure transponder, and tidal height
c       relative to North American Datum 1927 (NAD27).  According to
c       conventional practice, the free-air anomaly relative to NAD27
c       is calculated by applying both the free-air correction (-0.3086
c       mGal/meter) and a double Bouguer slab correction (+0.04103
c       mGal/meter) to account for station height and water depth.  The
c       free-air anomaly is then corrected to simple Bouguer by replacing
c       the underlying water layer (assumed density 1.03 g/cc) with rock of
c       an assumed average density of 2.67 g/cc.
c
c       The program also ties the observed gravity values into the North
c       American gravity network maintained by DMAHTC. The observed gravity re
c       into the program are relative values, and these are converted to
c       absolute values based on established network ties.
c
c
c       The following variable names are used:
c       Input:
c             sta      - station identifier
c             gobs     - observed gravity meter reading, corrected for
c                        meter drift and adjusted to a single base station
c             depth    - depth of gravimeter below water surface, in feet,
c                        positive downward
c             tide     - tidal height relative to NAD27, in feet,
c                        positive upward
c             dlat     - latitude of station
c             dlon     - longitude of station
c       Calculated:
```

```
c          height  - depth of gravimeter relative to NAD27
c                  = depth- tide
c          g67     - theoretical normal gravity based on 1967 formula
c          fac     - free-air correction
c          dbsc    - double Bouguer slab correction
c          sbc     - simple Bouguer correction
c     Output:
c          faa     - free-air anomaly
c          sbga    - simple Bouguer anomaly
c
c          depth, tide converted to meters on output
c
c
         double precision gobs,g67,gbase
         character*4 sta
         character*6 cruise
         character*8 moday
         gbase = 976390.289
         rho1 = 2.67
         rho2 = 1.03
         rho3 =  rho1- rho2
         iyr = 82
         cruise = "j482sf"
100      read(18,101,end=900) jd,ihr,min,sta,gobs,depth,tide,
       &                      ipt1,ipt2,var,dlat,dlon,moday
101      format(i3,1x,i2,i2,3x,a4,t93,f8.3,t83,f6.2,t75,f5.2,
       &        t35,2i2,t47,f6.1,t54,f9.5,f10.5,t105,a8)
         lat = int(dlat*100000.)
         lon = int(dlon*100000.)
c     Convert depth and tide from feet to meters
         depth = depth*0.3048
         tide = tide*0.3048
c     Convert latitude to radians
         rlat = dlat*0.01745329
         gobs = gobs + gbase
         g67 = 978031.85*(1+0.0053024*(sin(rlat)**2)
       &        -0.00000587*(sin(2*rlat)**2))
         height = depth-tide
         fac = 0.3086*height
         dbsc = 0.04193*rho2*(depth+height)
         faa = gobs - g67 - fac + dbsc
         sbc = 0.04193*rho3*height
         sbga = faa + sbc
c     Write output record
         write(19,102) iyr,jd,ihr,min,lat,lon,sta,ipt1,ipt2,var,
       &               gobs,g67,faa,depth,sbga,tide,moday,cruise
102      format(2(i3),2(i2),i8,i9,1x,a4,t91,2i2,1x,f5.1,
       &        t41,2(f9.2),f6.2,f6.1,f6.2,t83,f6.1,t103,a8,t115,a6)
         go to 100
900      continue
         end
```

APPENDIX B

```
1 REM     SF BAY TIDE CALCULATOR PROGRAM
2 INIT
3 GO TO 100
4 REM     REINITIALIZE TIDE VALUES
5 GOSUB 1000
6 RETURN
100 REM     SAN FRANCISCO BAY TIDE CALCULATION PROGRAM
110 REM     This program will calculate the tidal height of
120 REM     a point in the north San Francisco or San Pablo Bays
130 REM     from a series of input hourly tide values at Golden
140 REM     Gate and the time and amplitude differences from
150 REM     Golden Gate at high-high and low-low tides in the
160 REM     region of interest. These differences are published
170 REM     in the NOAA tide tables. The program works on an
180 REM     interpolation algorithm that calculates intermediate
190 REM     phase and amplitude differences based on the height
200 REM     of the tide relative to higher-high and lower-low. The
210 REM     method was further refined by using it to predict
220 REM     tides in the south San Francisco Bay for locations
230 REM     where measured tide values were available. This
240 REM     comparision suggested that the NOAA phase differences
250 REM     were about 60% to high, that the amplitude at high
260 REM     tides was about 50% too high, and that amplitude
270 REM     differences at lower-low tide were actually negative.
271 REM
272 REM     PROGRAM INSTRUCTIONS
273 REM     The program allows the user to enter tidal values
274 REM     (at Golden Gate) for a time period of not more than
275 REM     15 hours (assuming hourly readings). After the
276 REM     time/phase delays and tide readings have been entered,
277 REM     the user can then enter a station and observation
278 REM     time, and the program will write the corrected tide
279 REM     value to the screen and tape file. For a new day
280 REM     or location, use UD Key 1 to reinitialize the
281 REM     phase/amplitude differences and tide observations.
282 REM
289 DIM T(15),M(15),S$(4)
290 SET KEY
300 PRINT " NORTH SAN FRANCISCO BAY TIDE CALCULATION PROGRAM"
310 GOSUB 2000
320 GOSUB 1000
```

```
330 PRINT "  ENTER TIMES AS HOUR,MIN;  NEGATIVE HOUR ENDS PROGRAM"
340 PRINT " ENTER STATION ID;    ";
350 INPUT S$
360 PRINT "ENTER TIME:   ";
370 INPUT H0,M0
380 IF H0<0 THEN 500
390 IF H0=24 THEN 360
400 T0=D*24+H0+M0/60
410 FOR I=1 TO N
420 IF T0<T(I+1) THEN 440
430 NEXT I
440 REM     INTERPOLATE BETWEEN VALUES I AND I+1
450 M0=M(I)+(M(I+1)-M(I))*(T0-T(I))/(T(I+1)-T(I))
32: USING 480:S$,D,H0,(T0-(D*24+H0))*60,M0
33: USING 480:S$,D,H0,(T0-(D*24+H0))*60,M0
480 IMAGE 4a,"  APRIL ",2D,1X,2D,2D.1D,2X,2D.2D
490 GO TO 340
500 END
1000 REM     SUBROUTINE TO REINITIALIZE TIDE VALUES
1010 PRINT "  ENTER TIME DELAY AT HIGH-HIGH:   ";
1020 INPUT D1
1030 PRINT "ENTER TIME DELAY AT LOW-LOW:   ";
1040 INPUT D2
1050 PRINT "ENTER AMPLITUDE DIFFERENCE AT HIGH-HIGH:   ";
1060 INPUT D3
1070 PRINT "ENTER JULIAN DAY:   ";
1080 INPUT D
1090 REM     CONVERT JULIAN DAY TO APRIL, NON-LEAP YEAR
1100 D=D-90
1110 PRINT "ENTER OFFSET (SUBTRACTED):   ";
1120 INPUT O1
1130 PRINT " ENTER HOUR,TIDE VALUES; FINISH WITH NEGATIVE HOUR"
1140 FOR I=1 TO 15
1150 INPUT H0,M0
1160 M0=M0-O1
1170 IF H0<0 THEN 1220
1180 D0=D2+(D1-D2)*(M0+4)/8
1190 T(I)=D*24+H0+D0/60*0.6
1200 M(I)=M0+D3*(M0/6)
1210 NEXT I
1220 N=I-1
1230 RETURN
2000 REM    find tape file to write to
2010 PRINT " ENTER TAPE FILE NUMBER TO WRITE TO:   ";
2020 INPUT F1
2030 FIND F1
2040 RETURN
```

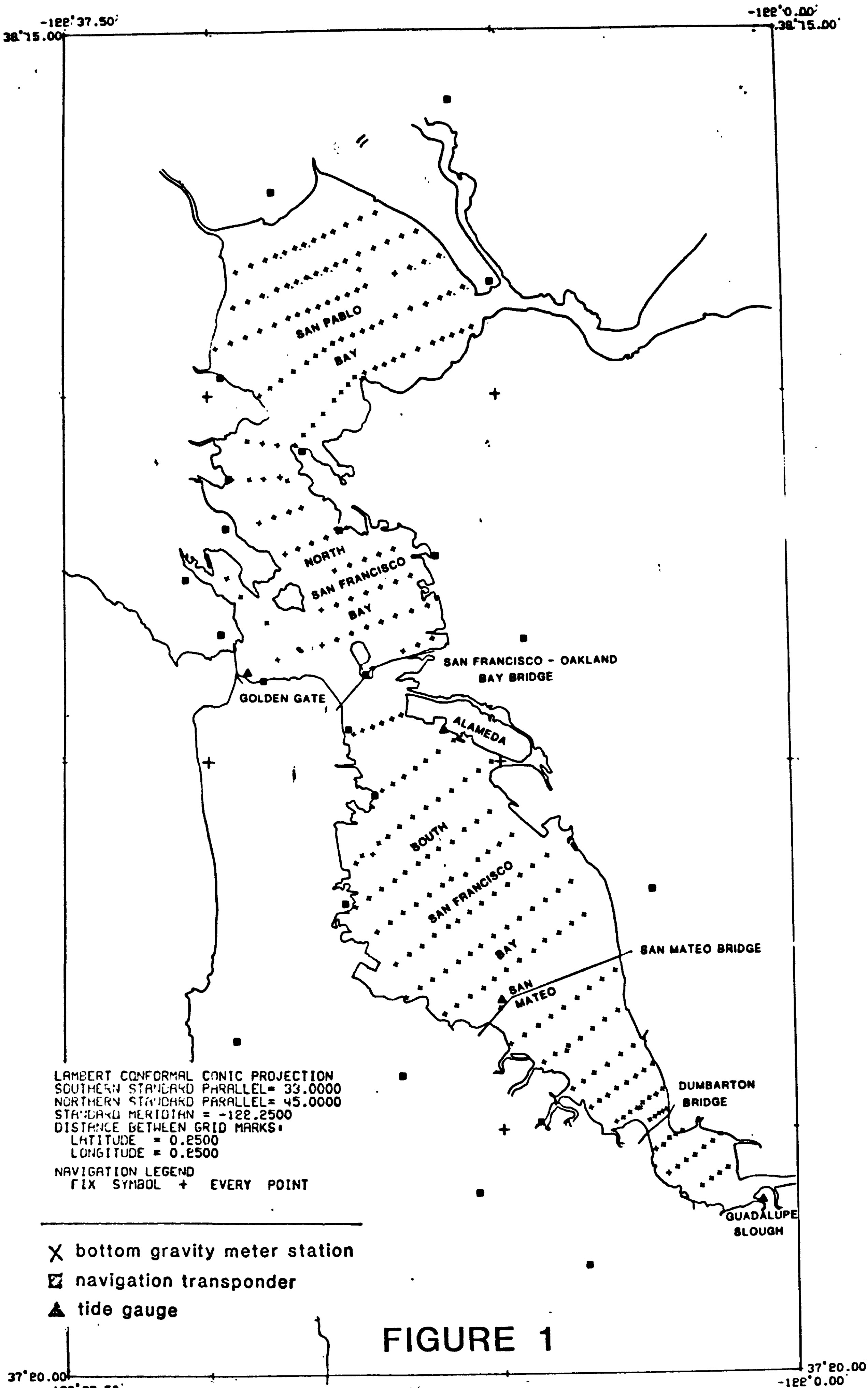
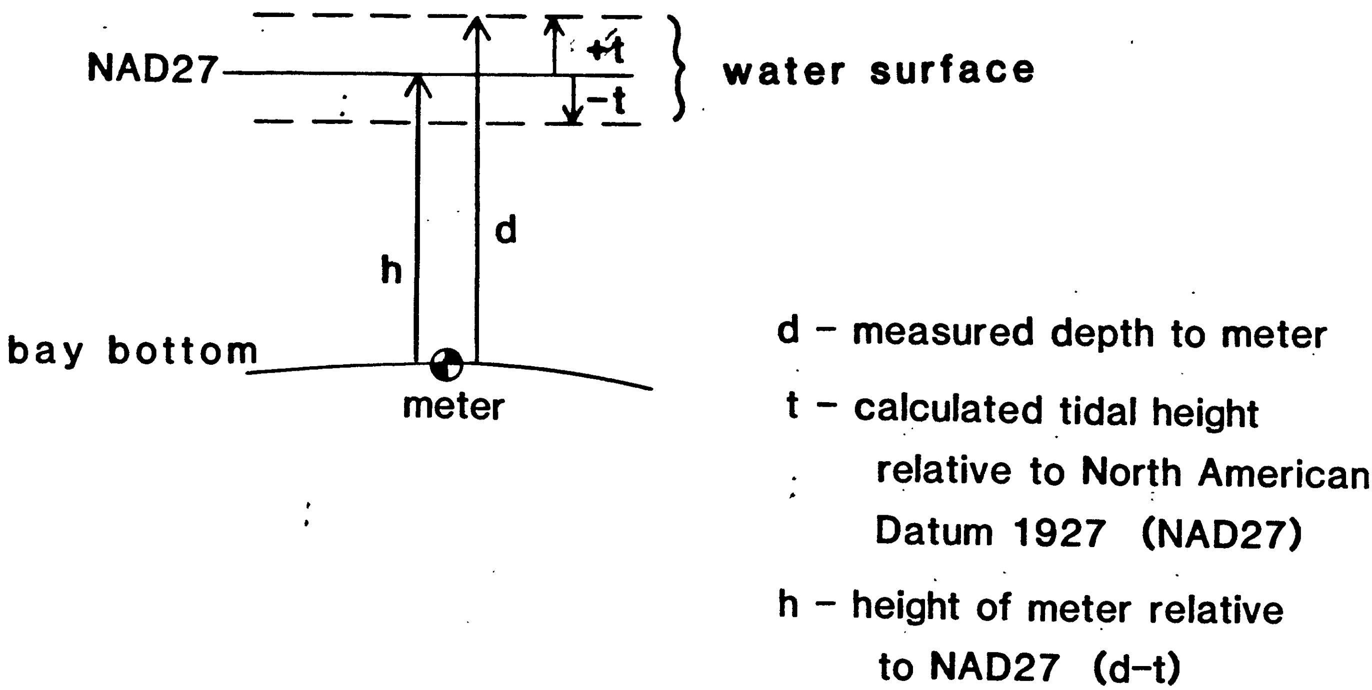

-122°37.50'
38°15.00'
-122°0.00'
38°15.00'
SAN PABLO
BAY
NORTH
SAN FRANCISCO
BAY
SAN FRANCISCO - OAKLAND
BAY BRIDGE
GOLDEN GATE
ALAMEDA
SOUTH
SAN FRANCISCO
BAY
SAN MATEO BRIDGE
SAN
MATEO
DUMBARTON
BRIDGE
GUADALUPE
SLOUGH
LAMBERT CONFORMAL CONIC PROJECTION
SOUTHERN STANDARD PARALLEL= 33.0000
NORTHERN STANDARD PARALLEL= 45.0000
STANDARD MERIDIAN = -122.2500
DISTANCE BETWEEN GRID MARKS:
LATITUDE = 0.2500
LONGITUDE = 0.2500
NAVIGATION LEGEND
FIX SYMBOL + EVERY POINT
X bottom gravity meter station
navigation transponder
tide gauge
37°20.00'
-122°37.50'
37°20.00'
-122°0.00'

FIGURE 1



Free-air gravity anomaly:

$$g_{faa} = g_{obs} - g_{67} - .3086h + 2\pi k\rho(h + d)$$

Simple Bouguer gravity anomaly:

$$g_{sba} = g_{faa} + 2\pi k(2.67 - \rho)h$$

where g_{obs} is observed gravity in milligals

g_{67} is normal gravity from 1967 Geodetic Reference System

h is depth of gravity meter beneath NAD27 in meters

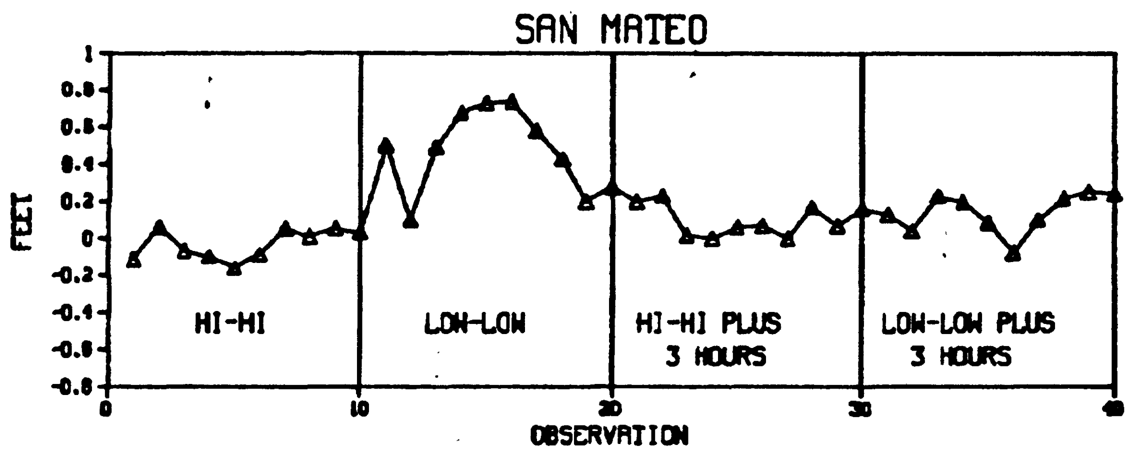
k is the universal gravitational constant

ρ is density of bay water assumed to be 1.01 g/cc

d is depth of gravity meter beneath sea surface in meters

(h and d are measured positive downward)

FIGURE 2



SAN MATEO
FEET
OBSERVATION
HI-HI
LOW-LOW
HI-HI PLUS 3 HOURS
LOW-LOW PLUS 3 HOURS

FIGURE 3

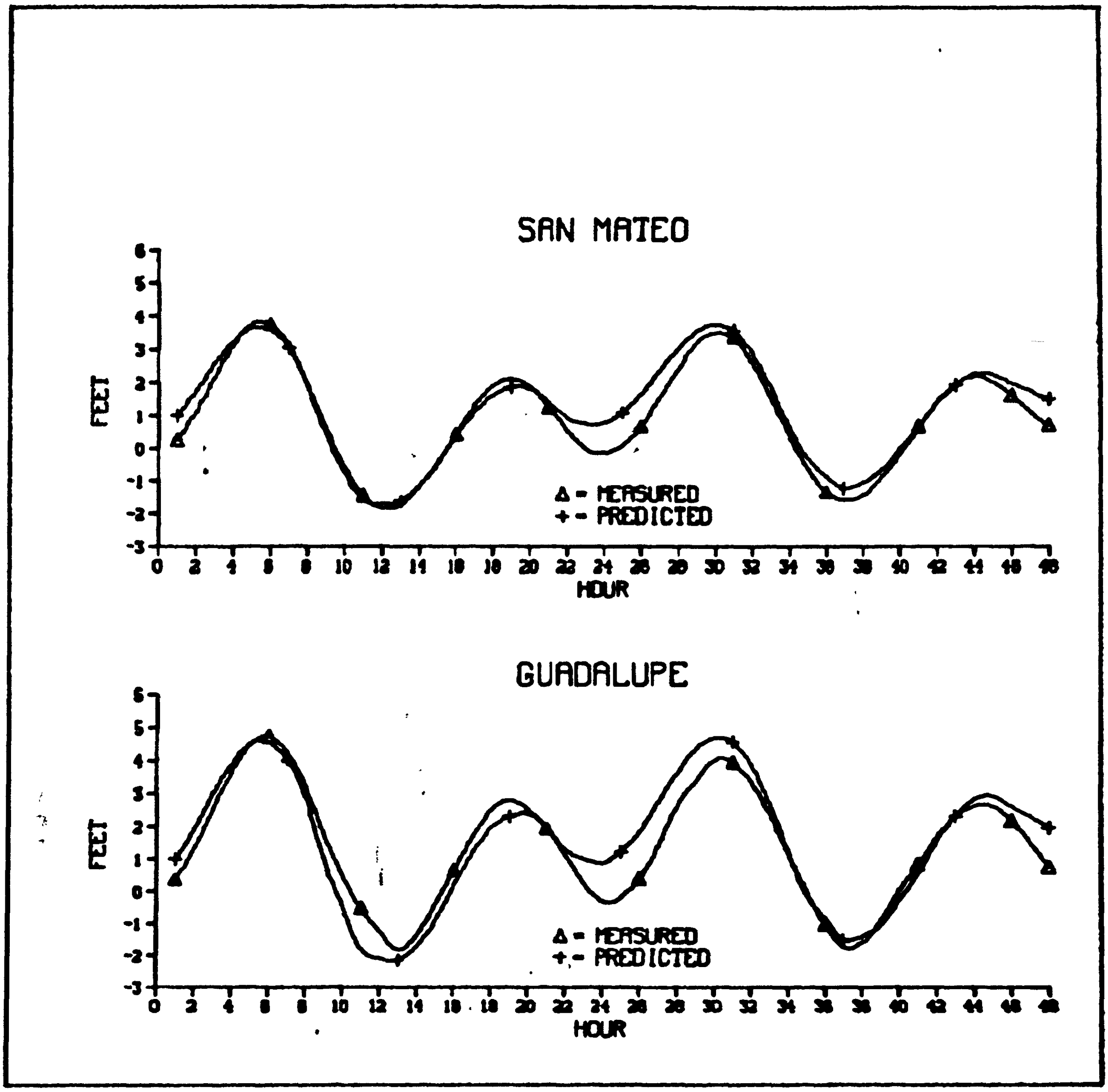
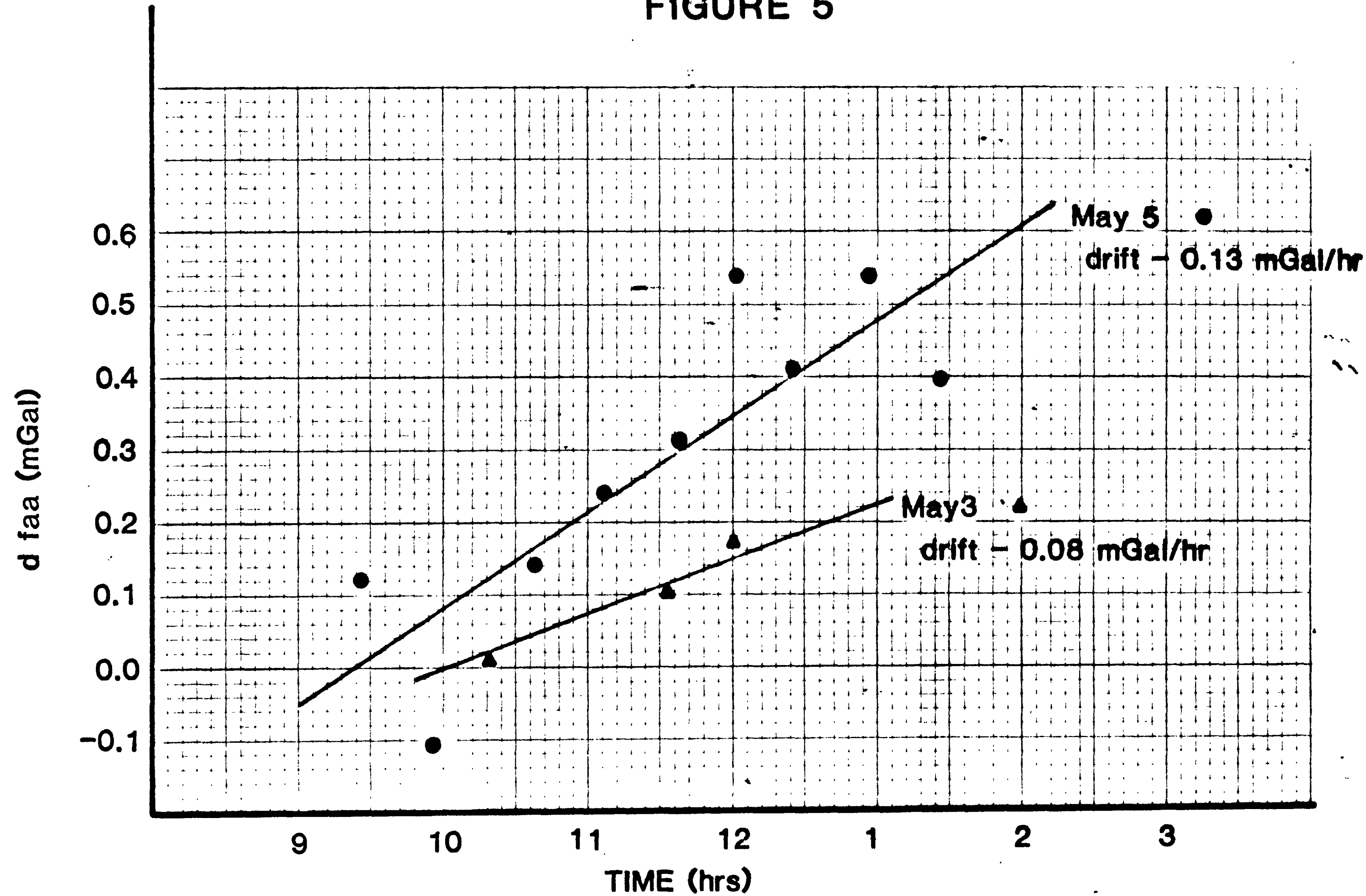

SAN MATEO
FEET
HOUR
Δ - MEASURED
+ - PREDICTED
GUADALUPE
FEET
HOUR
Δ - MEASURED
+ - PREDICTED

FIGURE 4

FIGURE 5



May 5
drift – 0.13 mGal/hr
May3
drift – 0.08 mGal/hr
0.6
0.5
0.4
0.3
0.2
0.1
0.0
−0.1
d faa (mGal)
9
10
11
12
1
2
3
TIME (hrs)