

Engineering Manual File Format Specification

Version: EM06

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1 Overview

The purpose of this document is to provide a detailed technical specification of the U.S. Army Corps of Engineers Engineering Manual (EM) survey file format. EM is an ASCII text-based file format, designed to be easy to create from survey data collector output, easy to read and understand, and easy to process with a computer program. Surveyors can use this document as a guide for creating EM files. Likewise, software developers can use this document as a basis for developing systems to read, write, and otherwise process survey data.

The EM file format was originally documented in the 1994 version of Engineering Manual EM-1005 [1]. The format was subsequently adopted by the New Orleans District of the U.S. Army Corps of Engineers (CEMVN) and its surveying contractors as a standard delivery product. The specification was updated in 2006 to accommodate vertical datum and tidal epoch relationships and published in the CEMVN Guide for Minimum Survey Standards for Performing Hydrographic, Topographic, and Geodetic Surveys [2]. Both specifications left several unresolved ambiguities in the file format. This document will define the organization of the EM file format and provide examples to help clarify it.

2 Organization

Contents of the EM file are divided into lines delimited by the newline character. Each line is limited to 80 characters in length. The character in the first column of a line determines how the line should be interpreted. There should be no blank lines in the file.

2.1 Comments

If the first column of a line is a semicolon (;), the line is treated as a comment. Comments are ignored by programs that read EM files. As such, comments are typically used to annotate different sections or improve readability of the survey file. The first line in Listing 1 is an example of a comment.

Listing 1 EM header example.

```
;This is a comment
#H02 05/20/2003
#M01 SHOT POINTS
101,450601.99,3457829.99,10.99,GRN
```

2.2 Records

If the first column of a line is a hash symbol (#), then the line is a record. Records define metadata information about the survey or attribution of survey features. The hash symbol is followed by a letter and two digits that determine the record type. Three special feature record codes (#X01, #P01, and #M01) are used to define survey features for cross-sections, profiles, and miscellaneous shot points, respectively.

The text that follows the record declaration is the record's contents. For example, line 2 in Listing 1 contains an #H02 record, which represents a survey date. In this case, the date is May 20, 2003. Under no circumstances should a record include a placeholder for unknown information. For example, a survey should not include #V03 N/A to indicate the surveyor does not know the vertical datum of the benchmark that was used. In such cases, the record should be omitted entirely.

2.3 Survey Points

All lines not beginning with either a semicolon or hash symbol are treated as survey points. Survey points represent individual locations, elevations, and classifications collected during the survey.

Survey points must be comma or space-delimited and must contain a record identifier followed by a northing, an easting, an elevation, and a feature code. An outline of the survey point structure is provided in Table 1. A survey point must be preceded by a line with a dataset record code (#X01, #P01, or #M01) so that the survey point can be associated to a cross-section line, profile line, or miscellaneous shot point group. Line 4 in Listing 1 shows an example of a survey point with unique identifier 101, a northing of 450601.99 and an easting of 3457829.99. The elevation of this survey point is 10.99 and the feature code is GRN, indicating that the shot was taken on natural ground. A list of commonly-used feature codes is included in Section 13. The survey point is preceded by an #M01 record on the third line, indicating that survey point 101 is logically associated with the SHOT POINTS feature.

Metadata for survey points is specified by the last record of a given type that precedes the survey point. Listing 2 indicates that the survey point with identifier 101 was surveyed on 05/20/2003 and that the point is a miscellaneous shot point. On the other hand, survey points with identifiers 102 and 103 in Listing 2 were surveyed on 05/21/2003 and are part of the MORE SHOT POINTS dataset, since a different #H02 and #M01 record precede them.

Listing 2 EM record and survey point example.

```

;This is a comment
#H02 05/20/2003
#M01 SHOT POINTS
101,450601.99,3457829.99,10.99,GRN
;
#H02 05/21/2003
#M01 MORE SHOT POINTS
102,500960.30,3700343.72,-11.10,SND
103,500954.99,3700362.88,-13.30,SND

```

Sequence	Definition	Type	Comments
1	Coordinate Id	String	Each survey point in a survey file must have a unique coordinate id. An integer value is preferred for the coordinate id.
2	Northing	Real	The northing value must be based on the units defined in the survey's units record(#H06), coordinate system (#H07), and horizontal datum(#H04).
3	Easting	Real	The easting value must be based on the units defined in the survey's units record(#H06), coordinate system (#H07), and horizontal datum(#H04).
4	Elevation	Real	The elevation value must be based on the preceding vertical control declaration (#V01 or #T01), vertical datum (#V04), epoch (#V03) and the survey's units record (#H06).
5	Feature Code	String	Survey point classification. Preferably, this value should be one of the codes listed in Table 13 or in the survey's CODES.DAT file.

Table 1: Survey point structure. The Sequence column represents the order in which the value appears in the survey point.

3 Survey Job Records

Survey job records define general metadata applicable to the survey file or the entire survey job. These records are distinguished by a #H prefix and should be placed before any other records in the file. Some header codes such as date (#H02), field book (#H10), and page number (#H11) may repeat within a survey file and additional records of these types should be added to the survey file when the date, page number or field book changes. Table 2 lists valid survey job record codes.

Record	Description	Type	Domain	Prerequisite	Repeatable?	Optional?	Comments
#H01	Filename	String			N	N	Original name of submitted survey file.
#H02	Date	Date (MM/DD/YYYY)			Y	N	All records and survey point entries are interpreted as having been collected on the date of the last preceding #H02 record. Multiple dates must not be put in a single #H02 record.
#H03	Vertical Accuracy Classification	String	1-I, 1-II, 2-I, 2-II, 3, 4		N	N	Vertical accuracy classification, as defined by the requester, based on USACE vertical accuracy standards documented in Engineering Manual EM1110-1-1004 [3].
#H04	Horizontal Datum	String	NAD83, NAD27		N	N	Horizontal datum of surveyed coordinates.
#H05	Job Number	String			N	N	Tracking number provided by USACE or requesting organization to uniquely identify a survey job.
#H06	Units of Measure	String	FT, M		N	N	Units of measure (feet or meters) used for horizontal and vertical components of survey coordinates.
#H07	State Plane Zone (FIPS)	String	1701, 1702, 1703		N	N	State plane zone to which coordinates are referenced. (Listed domain values are applicable in Louisiana.)
#H08	Location	String			N	N	Textual description of the survey locations for the survey file. Location may be used to distinguish one survey file from another amongst files that are a part of the same job.
#H09	Survey Organization	String			N	N	Name of organization that conducted the survey.
#H10	Field Book	String			Y	Y	Reference name of survey field book. All records and survey point entries are interpreted as having been documented in the field book of the last preceding #H10 record.
#H11	Page Number	String			Y	Y	Page number of survey field book. All records and survey point entries are interpreted as having been recorded on the page number of the last preceding #H11 record.
#H12	Combined Scale Factor	Real			N	Y	Ratio of the grid to ground/geodetic distances over the entire survey area.
#H13	County/Parish Name	String			Y	Y	County or parish in which the survey was primarily conducted.
#H14	Quad Name	String			Y	Y	USGS 7.5 minute quad name in which survey was primarily conducted.
#H15	Contract Number	String			N	Y	USACE contract number establishing the authority to conduct the survey.
#H20 - #H29	Job Title	String			N	N	Survey Job Title. This title should be consistent among all survey files that comprise an individual survey job and may be provided by USACE or requesting organization.
#H30 - #H99	Comments	String			Y	Y	General comments about survey job including horizontal and vertical accuracy, additional point of contact information, purpose of survey, and any difficulties that occurred during survey. If comments are longer than 80 characters, they may be continued on the following line, provided that the line is prepended with an #H30 - #H99 record code.

Table 2: Survey job record codes.

4 Vertical Control Records

All vertical control points (benchmarks), whether found or established, must be described by vertical control records in the survey file. Vertical control records define reference control parameters for survey point locations and elevations. There are two types of vertical control records. Permanent benchmarks, prefixed with #V records (defined in Table 3), are control points that are included in the National Geodetic Survey (NGS) network and are distinguished by PID numbers. Temporary benchmarks, prefixed with #T records (defined in Table 4), are control points that are marked by a physical monument, but are not defined in the context of the national network as of the date of the survey.

The #V01 and #T01 records, which represent benchmark names, define new benchmark declarations. All other #V and #T records should appear in the survey file after a #V01 or #T01 record. These supplemental records define properties of the previously declared benchmark. The last vertical control declaration that appears before a survey feature represents the vertical control upon which the feature's coordinates and elevation are based. This information is useful for applying vertical datum and epoch adjustments. Once declared, a vertical control declaration can be re-used elsewhere in the survey file by re-declaring the previously used #V01 or #T01 record. In these cases, it is not necessary to add the additional #V or #T records unless they are different. An example is shown in Listing 3. The ALCO and A 375 benchmarks are declared first with their respective vertical datum, epoch, and other attributes. ALCO has a documented elevation of 6.1 feet, while A 375 has a documented elevation of 0.2 feet. The first survey feature references the A 375 benchmark since it was the last vertical control record listed before the survey feature. The second and third survey features are referenced to ALCO since ALCO is re-declared. In practice, all survey projects must document the project's primary control point and the point(s) used to validate its elevation. So, each survey ought to contain a minimum to two vertical control records.

Record	Description	Type	Domain	Prerequisite	Repeatable?	Optional?	Comments
#V01	Name	String			Y	Y	Name of benchmark used in vertical control of the survey. This name should match the designation of a benchmark listed in the National Geodetic Survey (NGS) datasheets [4] unless explicitly directed by USACE or the requesting organization. All surveys should reference at least one permanent benchmark, but more may be required by the requesting organization.
#V02	Published Elevation	Real		#V01	N	N	Published elevation of permanent benchmark as specified by NGS datasheet or similar authority, specified using the units defined in the #H06 record.
#V03	Epoch	String	1938, 1951, 1955, 1963, 1968, 1976, 1984, 1986, 1992, 1994, 2004.65, 2006.81, OPUS, GULFNET, OTHER	#V01	N	N	Name of time period associated with the datum. See the FAQ[5] for more details.
#V04	Vertical Datum	String	NAVD88, NGVD29, MLG, MLLW, LMSL, LWRP, LWRP74, LWRP93	#V01	N	N	Vertical datum used for elevation reference.
#V05	Condition	String	GOOD, MONUMENTED, POOR, MARK NOT FOUND	#V01	N	N	Condition in which benchmark was found during the survey.
#V06	Measured Elevation	Real		#V01	N	Y	Benchmark elevation measured during survey using the units defined in the #H06 record.
#V07	Horizontal Coordinates	Real (Y,X)		#V01	N	N	Northing and easting of benchmark location using the units, datum, and state plane zone defined in the #H06, #H04, and #H07 records. This value is represented by a comma-separated pair of real numbers corresponding to a northing and easting value. Northing value must always precede the easting value.
#V08	PID	String		#V01	N	Y	NGS benchmark identifier. This is only required if the benchmark has an NGS PID.
#V09	Vertical Adjustment	Real		#V01	N	Y	Vertical adjustment. This adjustment is added to all subsequent survey point elevation values until the end of the file or until another #V09 record is specified. Vertical adjustments are used to translate surveys from one epoch to another or to correct surveys in which the measured benchmark elevation does not match the documented benchmark elevation.
#V10	Local Mean Sea Level Relationship	Real		#V01	N	Y	Established local mean sea level water surface elevation for the vicinity of the benchmark in units defined in the #H06 record minus the published elevation of the benchmark (#V02 record)[LMSL - #V02]. Local mean sea level elevation should be based on the National Tidal Epoch Period (#V12).
#V11	Mean Lower Low Water Relationship	Real		#V01	N	Y	Established mean lower low water surface elevation for the vicinity of the benchmark in units defined in the #H06 record minus the published elevation of the benchmark (#V02 record)[MLLW - #V02]. Mean lower low water elevation must be based on the National Tidal Epoch Period (#V12).
#V12	National Tidal Datum Epoch Period	See Description		#V01	N	Y	Starting and ending years of the period used to define sea level (#V10) and/or mean lower low water (#V11) for the area in the vicinity of the benchmark. The format of this value is a starting and ending year represented as integers separated by a dash (For example: 1983-2001).
#V20 - #V99	Description	String		#V01	Y	Y	Textual description of permanent benchmark. If benchmark description is longer than 80 characters, the description may be continued on the following line, provided that line is prepended with a #V20-#V99 record code.

Table 3: Permanent benchmark record codes. If a prerequisite is defined for a given record code, then the repeatable and optional parameters apply to instances of the given record code that occur between instances of the prerequisite code.

Listing 3 Multiple vertical control example. Survey feature 1 references the A 375 benchmark, while features 2 and 3 reference the ALCO benchmark.

```
; Vertical Control Information
#V01 ALCO
#V02 6.1
#V03 2004.65
#V04 NAVD88
#V05 GOOD
#V06 6.14
#V07 557299.69,3667048.45
#V08 BJ1342
;
; Vertical Control Information
#V01 A 375
#V02 0.2
#V03 2004.65
#V04 NAVD88
#V05 GOOD
#V06 0.2
#V07 575567.53,3720265.83
#V08 BH1811
;
; Survey Feature 1 : References A 375 benchmark
;
#X01 3087987.07 603432.45 3088120.65 603414.41 12100.00 121+00
13205,603421.06,3088071.14,16.05,TBK
13213,603423.05,3088056.70,3.72,THG
13223,603426.21,3088036.43,16.22,TBK
;
; Re-declaration of ALCO benchmark
;
#V01 ALCO
;
; Survey Feature 2: References ALCO Benchmark
;
#X01 3087993.16 603453.37 3088122.69 603436.39 12200.00 122+00
13174,603443.28,3088073.66,16.38,TBK
13181,603446.09,3088059.18,4.09,THG
13188,603446.69,3088045.62,16.02,SLP
;
; Survey Feature 3: Still References ALCO Benchmark
;
#X01 3087922.16 603481.37 3088745.69 603455.39 12300.00 123+00
13194,603451.95,3088003.68,16.77,NG
13195,603452.85,3087996.99,16.90,NG
```

Record	Description	Type	Domain	Prerequisite	Repeatable?	Optional?	Comments
#T01	Name	String			Y	Y	Name of temporary benchmark as designated by USACE or other requesting agency.
#T02	Published Elevation	Real		#T01	N	Y	Published elevation of temporary benchmark as provided by USACE or other requesting agency.
#T05	Condition	String	GOOD, MONU- MENTED, POOR, MARK NOT FOUND	#T01	N	N	Condition in which benchmark was found during the survey.
#T06	Measured Elevation	Real		#T01	N	N	Benchmark elevation measured during survey using the units defined in the #H06 record.
#T07	Horizontal Coordinates	Real (Y,X)		#T01	N	N	Northing and easting of benchmark location using the units, datum, and state plane zone defined in the #H06, #H04, and #H07 records. This value is represented by a comma-separated pair of real numbers corresponding to a northing and easting value. Northing value must always precede the easting value.
#T10 - #T99	Description	String		#T01	Y	Y	Textual description of temporary benchmark. If benchmark description is longer than 80 characters, the description may be continued on the following line, provided that line is prepended with a #T10-#T99 record code.

Table 4: Temporary benchmark record codes. If a prerequisite is defined for a given record code, then the repeatable and optional parameters apply to instances of the given record code that occur between instances of the prerequisite code.

5 Gage Records

Gage records must be included in hydrographic surveys whenever a gage is read over the course of a survey. Sounding elevations are calculated from a depth reading and gage reading of the water surface elevation. As the water surface elevation may be influenced by tides, it is also important to capture the date and time of the water surface elevation. A gage is declared with a gage name (#G02) record. The first use of the game name record can be preceded by the gage identifier record (#G01) if the gage is provided by USACE, NOAA, or another authoritative entity. The last vertical control record (#T01 or #V01) listed before the initial declaration of a gage is assumed to be the basis of the gage’s calibration. Once a gage is declared, its readings can be recorded as water surface elevation (#G03) and time (#G04) records. Table 5 lists valid gage record codes. Hydrographic survey features are referenced to the last name (#G02), time (#G03), and water surface elevation (#G03) that precede the survey feature. In Listing 4, gage G-1 is read once at 7:00 and used to reference the first cross-section. The same gage is read again at 13:00 and used to reference the second cross-section. Refer to the engineer manual for hydrographic surveying [6] for guidance on gage usage.

Record	Description	Type	Domain	Prerequisite	Repeatable?	Optional?	Comments
#G01	Gage Id	String			Y	Y	USACE, USGS, or NOAA gage id.
#G02	Name	String			Y	Y	Gage Name.
#G03	Water Surface Elevation	Real		#G02	N	N	Water surface elevation read at the gage, based on units in the survey's #H06 record.
#G04	Gage Reading Time	Time (HHMM)		#G02	N	N	Time of gage reading in military units (0000 - 2359).
#G05	Local Mean Sea Level Reference	Real		#G02	N	Y	Water surface elevation (based on units in the survey's #H06 record) at the gage site relative to the survey's vertical datum and epoch when the water level is at its local mean sea level. If the gage zero is set to local mean sea level, then this value can be subtracted from gage readings to calculate the water surface elevation relative to the survey's vertical datum (#V04) and epoch (#V03): $Z_{\#G03} - Z_{\#G05} = Z_{\#V03, \#V04}$
#G06	Mean Lower Low Water Reference	Real		#G02	N	Y	Water surface elevation (based on units in the survey's #H06 record) at the gage site relative to the survey's vertical datum and epoch when the water level is at its mean lower low water (the average lower water surface elevation between the two low tides). If the gage zero is set to mean lower low water, then this value can be subtracted from gage readings to calculate the water surface elevation relative to the survey's vertical datum (#V04) and epoch (#V03): $Z_{\#G03} - Z_{\#G06} = Z_{\#V03, \#V04}$
#G07	Horizontal Coordinates	Real (Y,X)		#G02	N	Y	Northing and easting of gage location measured using the units, datum, and state plane zone defined in the #H06, #H04, and #H07 records. This value is represented by a comma-separated pair of real numbers corresponding to a northing and easting value. Northing value must always precede the easting value.
#G10 -#G99	Description	String		#G02	Y	Y	Gage Description. If gage description is longer than 80 characters, the description may be continued on the following line, provided that line is prepended with a #G10-#G99 record code.

Table 5: Gage record codes. If a prerequisite is defined for a given record code, then the repeatable and optional parameters apply to instances of the given record code that occur between instances of the prerequisite code.

Listing 4 Gage example. Survey feature 1 references gage G-1 at 7:00 AM. Survey feature 2 references gage G-1 at 1:00 PM. Reuse of G-1 requires only the #G02, #G03, and #G04 records.

```
; Survey Date
#H02 10/10/2002
; Vertical Control Information
#V01 ALCO
#V02 6.1
#V03 2004.64
#V04 NAVD88
#V07 557299.69,3667048.45
;
; Gage information
;
; First gage, G-1, referenced to ALCO
;
#G02 G-1
#G03 0.32
#G04 0700
#G05 0.2
#G07 557279.69,3667058.45
#G10 TEMPORARY STAKE GAGE SET AT END OF CANAL
;
; Survey Feature 1 : Sounding elevations (SND)
; are calculated relative to water surface elevation
; of gage G-1 at 0700 hours (7:00 AM).
;
#X01 3087987.07 603432.45 3088120.65 603414.41 12100.00 121+00
13205,603421.06,3088071.14,16.05,TBK
13213,603423.05,3088056.70,-3.72,BOT
13223,603426.21,3088036.43,16.22,TBK
;
; Gage G-1 reading at 13:00
;
#G02 G-1
#G03 0.1
#G04 1300

;
; Survey Feature 2 : Sounding elevations (SND)
; are calculated relative to water surface elevation
; of gage G-1 at 1300 hours (1:00 PM).
;
#X01 3087993.16 603453.37 3088122.69 603436.39 12200.00 122+00
13174,603443.28,3088073.66,-16.38,SND
13181,603446.09,3088059.18,-20.09,SND
13188,603446.69,3088045.62,-16.02,SND
```

6 Equipment Records

Equipment records describe the equipment used to collect survey points. A piece of equipment is declared with an #E01 record. Once the equipment record is declared, additional information such as serial number (#E02) and instrument type (#E03) can be added. Table 6 describes the equipment record codes.

Record	Description	Type	Domain	Prerequisite	Repeatable?	Optional?	Comments
#E01	Instrument	String			Y	Y	Name of an instrument used during the survey.
#E02	Serial Number	String		#E01	N	Y	Instrument serial number.
#E03	Instrument Type	String	LEVEL, TOTAL STATION, GPS, RTK, VRS, SONAR, OTHER	#E01	N	Y	Type of survey equipment.

Table 6: Equipment record codes. If a prerequisite is defined for a given record code, then the repeatable and optional parameters apply to instances of the given record code that occur between instances of the prerequisite code.

7 Crew Records

Crew records are used to identify the individuals who participated in a survey and their team roles. Table 7 describes the crew record codes. An example is shown in Listing 5.

Record	Description	Type	Domain	Prerequisite	Repeatable?	Optional?	Comments
#C01	Party Chief	String			Y	Y	Name of party chief.
#C02	Instrument Man	String			Y	Y	Name of instrument person.
#C03	Rodman	String			Y	Y	Name of rodman.
#C04-#C99	Miscellaneous Crew Member	String			Y	Y	Name of an individual who participated in the survey, but was not the party chief, rodman, or instrument man.

Table 7: Crew record codes. If a prerequisite is defined for a given record code, then the repeatable and optional parameters apply to instances of the given record code that occur between instances of the prerequisite code.

Listing 5 Crew example. First initials and last names are used for these crew record entries.

```

; Party Chief
;
#C01 S. GUERRA
;
; Instrument Personnel
;
#C02 W. CASHEN
#C02 S. FALCHOOK
;
; Rod Personnel
;
#C03 C. HUNTER
;
; Truck Driver
;
#C04 M. AURAND

```

8 Weather Records

Weather records are used to record weather conditions at the time of the survey. A weather observation must include a temperature record code (#W01) as a minimum and must be preceded by a date record (#H02) on which the weather was observed. Table 8 lists the valid weather record codes that can be used to describe the weather during the time of the survey. All weather record data should include the measurement followed by units or a percentage sign (%) where applicable as demonstrated in Listing 6. In this example, two weather observations were made on the same day.

Record	Description	Type	Domain	Prerequisite	Repeatable?	Optional?	Comments
#W01	Temperature	String		#H02	N	N	Observed temperature.
#W02	Air Pressure	String		#H02	N	Y	Observed air pressure.
#W03	Humidity	String		#H02	N	Y	Observed humidity measured as a percentage.
#W04	Cloud Conditions	String		#H02	N	Y	Cloud coverage measured as a percentage.
#W05	Wind Speed	String		#H02	N	Y	Observed wind speed.
#W06	Wind Direction	String	N, S, E, W, NE, SE, SW, NW	#H02	N	Y	Observed wind direction.

Table 8: Weather record codes. If a prerequisite is defined for a given record code, then the repeatable and optional parameters apply to instances of the given record code that occur between instances of the prerequisite code.

Listing 6 Weather example. The second observation shows the change in temperature from 85 degrees to 95 degrees.

```

;
; First weather observation
;
#H02 10/10/2002
;
#W01 85 DEGREES
#W02 30.02 INCHES
#W03 68%
#W04 10%
#W05 5 MPH
#W06 SE
;
; Second weather observation
;
#H02 10/10/2002
;
#W01 95 DEGREES
;

```

9 Baseline Records

Baseline records are used to define points of inflection along the baseline of a survey. Baseline points include the easting, northing, and numerical station value of the baseline point. Cross-sections and profiles are typically referenced to positions along a baseline identified by a station value. Typically, multiple survey files in the same job will reference the same baseline. In these cases, the #B00 record can be used to specify a separate baseline file.

The syntax of a baseline file is the same as the syntax of a regular EM file. However, a baseline file may not include any cross-section (#X01), profile (#P01), or miscellaneous shot point(#M01) records. A baseline file name must have a .bl (or .BL) extension and should include a series of station coordinate records that include easting, northing, and station of a point along the baseline. Baseline points must be listed in sequential order. The baseline record codes are listed in Table 9. An example is shown in Listing 7 (the EM file with #B00 record) and Listing 8 (the baseline associated to the EM file).

Record	Description	Type	Domain	Prerequisite	Repeatable?	Optional?	Comments
#B00	Baseline File Reference.	String			N	Y	Relative path and filename of baseline, if a separate file is used. Unix or DOS path separators may be used, if necessary.
#B01 - #B999	Station Coordinate	See Description			Y	N	Baseline coordinate represented as an easting and northing coordinate followed by a station value. Easting, northing, and station are all real values and should be separated by spaces (X Y STAT). The easting value always precedes the northing value for baseline points. If more than 100 baseline points are required, #B100-#B999 can be used.

Table 9: Baseline record codes. If a prerequisite is defined for a given record code, then the repeatable and optional parameters apply to instances of the given record code that occur between instances of the prerequisite code.

Listing 7 Baseline example. The EM survey file, 061005.EM includes a reference to the baseline file, 061005.BL on the sixth line using a #B00 record.

```

; Contents of 061005.EM
; Header information
#H01 061005.EM
#H02 10/10/2002
;
#B00 061005.BL
;
#X01 3087987.07 603432.45 3088120.65 603414.41 1.00 UPSTREAM
13205,603421.06,3088071.14,16.05,TBK
13213,603423.05,3088056.70,3.72,SND
13223,603426.21,3088036.43,16.22,TBK

```

Listing 8 Baseline example. The Baseline file, 061005.BL includes station coordinate record codes(#B01-#B999), followed by easting, northing, and station.

```
; Contents of 061005.BL
#B01 308109.34 603499.28 0.0
#B02 308122.55 603515.44 385.10
#B03 308137.92 603527.81 415.22
;
```

10 Cross-Section Data Records

Cross-section records precede a collection of survey points that comprise a cross-section, a survey feature that is taken across a waterway, levee, or other physical feature that is linear in nature. A cross-section is declared by an #X01 record, which includes the range line starting and ending points. The range line defines the name of a location that is surveyed repeatedly to compare the feature's topography with itself over time. The #X01 record defines the starting and ending point coordinates of the cross-section, its station number, and its name. The cross-section station numerically defines the position of the cross-section along the path of the physical feature being surveyed. All survey points that appear between the #X01 record and the next #X01, #M01, or #P01 record are associated exclusively to that cross-section. The survey points for a cross-section are not required to be in any specific order. Software programs that implement the EM format should sort the cross-section points in ascending order based on the projected distance of the cross-section points from the range line start point to the range line end point.

Additional information can be added to a cross-section definition, including range name (#X02), cross-section time (#X03), and assumed water surface elevation (#X04). The range name is only needed if the range name is different from the cross-section name. The cross-section time record is used to record the surveying start time of a hydrographic cross-section. The assumed water surface elevation is reported when the water surface elevation used to calculate cross-section elevations has been interpolated from multiple gages. Otherwise, the gage record water surface elevation (#G04) is sufficient. Descriptions of the cross-section record codes are provided in Table 10.

Cross-section elevations are referenced to the preceding benchmark reference (#V01 or #T01) and gage reference (#G02, #G03, and #G04) records, if applicable. The date on which the cross-section was surveyed is reflected by the preceding date record(#H02). If field book information is recorded, then the book name and page numbers are reflected by the preceding field book (#H10) and page number (#H11) records. Listing 9 shows a single cross-section named XSEC1 that has starting range line coordinate (3664412.798, 554165.117), ending range line coordinate (3664639.354, 554144.167), and station 153.57. The survey points that follow are associated to XSEC1.

Record	Description	Type	Domain	Prerequisite	Repeatable?	Optional?	Comments
#X01	Start of a Cross-Section Feature	See Description			Y	Y	Cross-section initializer. Starting and ending easting and northing value pairs corresponding to the starting and ending coordinates of the cross-section range line, followed by the station and the cross-section identifier (X1 Y1 X2 Y2 STAT NAME). Values are separated by a single space and eastings precede northing values. X1, Y1, X2, Y2, and STAT are Real values. NAME is a text value that may contain spaces. All survey points that follow up to the next #X01, #P01, or #M01 record are associated with the same cross-section.
#X02	Range Name	String		#X01	N	Y	Name of the associated cross-section range line, if one exists.
#X03	Cross-Section Start Time	Time (HHMM)		#X01	N	Y	Start time of cross-section data sampling.
#X04	Water Surface Elevation	Real		#X01	N	Y	Cross-section water surface elevation calculated for the start of cross-section sampling.

Table 10: Cross-section record codes. If a prerequisite is defined for a given record code, then the repeatable and optional parameters apply to instances of the given record code that occur between instances of the prerequisite code.

Listing 9 Cross-section example. In the #X01 record, coordinates (3664412.798, 554165.117) and (3664639.354, 554144.167) represent the range line end points. 153.57 is the station number of the cross-section relative to its baseline. XSEC1 is the name of the cross-section.

```
#X01 3664412.798 554165.117 3664639.354 554144.167 153.57 XSEC1
4,554165.117,3664412.798,12.189,TCW
6,554163.858,3664422.424,4.071,CRN
7,554162.375,3664434.061,0.842,SLP
8,554160.171,3664446.333,-1.525,TOE
10,554157.192,3664478.962,-3.013,NG
19,554144.167,3664639.354,-5.774,FL
```

11 Profile Data Records

Profile records precede a collection of survey points that comprise a profile, a survey feature that is taken along the path of a waterway, levee, or other physical feature that is linear in nature. A profile is declared by a #P01 record, which includes the starting point coordinate, starting station, and name of the profile. Profile points must be recorded in order and a profile line must not intersect itself. All survey points that appear between the #P01 record and the next #X01, #M01, or #P01 record are associated exclusively to that profile.

Additional information can be added to a profile definition, including profile time (#P03) and assumed water surface elevation (#P04). The profile time record is used to record the surveying start time of a hydrographic profile. The assumed water surface elevation is reported when the water surface elevation used to calculate profile elevations has been interpolated from multiple gages. Otherwise, the gage record water surface elevation (#G04) is sufficient. Description of the profile record codes is provided in Table 11.

Profile elevations are referenced to the preceding benchmark reference (#V01 or #T01) and gage reference (#G02, #G03, and #G04) records, if applicable. The date on which the profile was surveyed is reflected by the preceding date record (#H02). If field book information is recorded, then the book name and page numbers are reflected by the preceding field book (#H10) and page number (#H11) records. If the reference benchmark, gage, or date changes in the middle of a profile, then a new profile should be defined that continues from the previous profile (including the last point from the previous profile). Listing 10 shows a single profile named MUGL that has starting coordinate (3698572.642, 530389.323) and station 10.0. The survey points that follow are associated to MUGL.

Record	Description	Type	Domain	Prerequisite	Repeatable?	Optional?	Comments
#P01	Start of Profile Feature	See Description			Y	Y	Profile initializer. Starting easting and northing of the profile, followed by the profile's starting station and name (X Y STAT NAME). Values are separated by a single space. X, Y and STAT are real numbers. NAME is a text value that may contain spaces. All survey points that follow up to the next #X01, #P01, or #M01 record are associated with the same profile.
#P03	Profile Start Time	Time (HHMM)		#P01	N	Y	Start time of profile data sampling.
#P04	Water Surface Elevation	Real		#P01	N	Y	Profile water surface elevation calculated for the start of profile sampling.

Table 11: Profile record codes. If a prerequisite is defined for a given record code, then the repeatable and optional parameters apply to instances of the given record code that occur between instances of the prerequisite code.

Listing 10 Profile example. In the #P01 record, the coordinate (3698572.642, 530389.323) is used as the starting point, 10.0 is the starting station, and MUGL is the name of the profile.

```
#P01 3698572.642 530389.323 10.0 MUGL
190,530119.038,3698954.414,20.468,CLL
191,530091.177,3699005.658,20.553,CLL
192,530057.379,3699067.854,20.363,CLL
```

12 Miscellaneous Data Records

Miscellaneous shot point records precede a collection of survey points that are not part of a profile or cross-section feature. A miscellaneous shot point group is declared by an #M01 record. The #M01 record includes a textual description of the common properties of the subsequent survey points. If the textual description exceeds 80 characters, it may be continued on the next line by additional #M records that precede the survey points. All survey points that appear between the #M01 record and the subsequent #X01, #M01, or #P01 record are associated exclusively to that miscellaneous shot point group. Descriptions of miscellaneous shot point record codes are provided in Table 12.

Miscellaneous shot point elevations are referenced to the preceding benchmark reference (#V01 or #T01). The date on which the shot points were surveyed is reflected by the preceding date record (#H02). If field book information is recorded, then the book name and page numbers are reflected by the preceding field book (#H10) and page number (#H11) records. Survey points that have different benchmark references or survey dates should not be included in the same miscellaneous shot point group.

Record	Description	Type	Domain	Prerequisite	Repeatable?	Optional?	Comments
#M01 - #M99	Miscellaneous shot points	String			Y	N	Miscellaneous shot points initializer. All survey points that follow up to the next next #X01, #P01, or #M01 record are associated with the same miscellaneous shot point group.

Table 12: Miscellaneous Shot Point Record Codes. If a prerequisite is defined for a given record code, then the repeatable and optional parameters apply to instances of the given record code that occur between instances of the prerequisite code.

13 Feature Codes

Feature codes appear at the end of each survey point and typically contain two or three consecutive upper-space characters that store an abbreviated code for the type of survey point. Commonly-used feature codes are shown in Table 13. If a feature code is not listed in Table 13, an additional text file named CODES.DAT may be submitted with the survey. This file should reside in the same directory as the survey file and should include a semi-colon delimited list of three-letter feature codes and their definitions. Each line in the CODES.DAT file must contain only one code/definition pair and the file may not contain any blank lines.

Code	Definition	Code	Definition
AC	TOP OF A.C. PAD	CLB	CENTERLINE OF BRIDGE
AP	ABANDONED PIPE	CLC	CENTER OF CONCRETE
APR	APRON	CLD	CENTER OF DITCH
ASP	ASPHALT	CLI	CENTERLINE
ATO	ABUTMENT TOE	CLR	CENTERLINE OF ROAD
ATP	ABUTMENT TOP	CLW	CENTERLINE OF WALKWAY
BAL	BALLAST	CND	CONDUIT
BBP	BOTTOM OF BORROW PIT	CNL	CANAL
BBT	BOTTOM OF BENT	COH	CONCRETE HEAD WALL
BCR	BRIDGE CORNER	CON	CONCRETE
BFB	BRICK FLOWER BED	COR	CORNER
BF	BRIDGE FENDER	CP	CYPREMER TLE TREE
BL	BASELINE	CPG	CONCRETE PILING
BM	BENCH MARK	CPT	CYPRESS TREE
BLD	BUILDING	CRD	CROWN OF DIKE
BLK	BULKHEAD	CRK	CENTERLINE ROCK
BNT	BENT OF BRIDGE	CRA	CENTERLINE OF RAIL
BOD	BOTTOM OF DITCH	CRB	CURB
BOS	BOTTOM OF STREAM	CR	CROWN OF LEVEE
BOT	BOTTOM	CRN	CROWN
BRC	BRIDGE CONCRETE	CRT	CROSSTIE
BRF	BRIDGE FENDER	CRW	CONCRETE RETAINING WALL
BRK	BREAKLINE	CSP	CONCRETE AT SWIMMING POOL
BRW	BREAK WALL	CTD	CENTER OF DRAIN
BS	BUSH	CTH	CATCH BASIN
BW	BRICK WALL	CTN	COTTONWOOD TREE
CAR	CENTERLINE OF AGGREGATE ROAD	CUB	BOTTOM OF CULVERT
CAP	CONCRETE APRON	CUL	CULVERT
CA	CONCRETE ASPHALT	CYP	CYPRESS TREE
CB	CATCH BASIN	CYS	CYPRESS TREES
CBC	CABLE LINE	DGS	DOGWOOD TREES
CBK	CONCRETE BULKHEAD	DKE	DIKE
CBL	CABLE	DRI	DROP INLET
CBT	CONCRETE BLUT TOE	DRN	DRAIN
CCL	CENTERLINE OF CONCRETE CULVERT	DDR	DEAD DOG ON ROAD
CCP	CENTERLINE OF CONCRETE PAD	DRV	DRIVE
CCR	CENTERLINE OF CONCRETE CURB	EAR	EDGE OF AGGREAGATE ROAD
CDR	CONCRETE DRIVE	ECR	EDGE CONCRETE BRIDGE
CFP	CORNER FLAG POLE BASE	EC	EDGE CONCRETE
CG	CATTLE GUARD	ECC	EDGE CONCRETE CURB
CH	CORNER HOUSE	ECR	EDGE CONCRETE ROAD
CHW	CENTERLINE OF HEAD WALL	ECW	EDGE OF WALL
CLG	CENTERLINE GABION	EDR	EDGE OF DIRT ROAD
CL	CENTERLINE	EFB	EDGE OF FLOWER BED

Code	Definition	Code	Definition
EGL	EDGE OF GRASS LINE	GVL	GAS VALVE
ELS	EDGE OF LIMESTONE	HBK	HIGH BANK
ELM	ELM TREE	HBS	HACKBERRY TREES
ELS	ELM TREES	HED	HEDGES
EMG	EDGE OF METAL GRATING	HL	HEDGE LINE
EOA	EDGE OF ASPHALT	HSE	HOUSE
EOB	EDGE OF BRIDGE	HT	10" HACKBERRY TREE
EOC	EDGE OF CULVERT	HUB	HUB
EOR	EDGE OF RIP RAP	HWL	HEAD WALL
EOM	EDGE OF MEDIAN	HYD	FIRE HYDRANT
EP	EDGE OF PLATFORM	INV	PIPE INVERT
EPL	EDGE OF PARKING LOT	IP	IRON PIPE
ER	EDGE OF ROAD	IRL	IRON RAIL
ERF	EDGE OF ROAD FLOOD SIDE	IR	IRON ROD
ERP	EDGE OF ROAD PROTECTED SIDE	LC	LOW CORD
ESH	EDGE SHELL ROAD	LDR	LIDAR
ESL	EDGE OF SLAG ROAD	LPL	LIGHT POLE
ESP	EDGE SHEET PILE	LW	LOW WIRE
ESR	EDGE SHELL ROAD	MB	MULLBERRY TREE
EW	EDGE WOODS	MBX	MAIL BOX
FEP	FENCE POST	MET	METAL/TOP OF GATES
FC	FENCE CORNER	MF	MUD FLAT
FIP	4" POST	MGT	MAGNOLIA TREE
FL	FENCE LINE	MH	MANHOLE COVER
FLB	FENCE LINE BRICK	MON	MONUMENT
FLC	FENCE LINE CHAIN LINK FENCE	MSH	MARSH
FLD	FLOOD WALL	MTR	METER
FLW	FENCE LINE WOODEN	MTX	METER BOX
FP	FLY POINT	NG	NATURAL GROUND
FS	FLOOD SIDE LEVEE	NGP	NATURAL GROUND AT PILING
FSC	FLOOD SIDE CROWN	NS	NORTH SIDE
FST	FLOOD SIDE TOE	OH	OVERHEAD POWER LINES
FTG	FOOTING	OT	OAK TREE
GAC	GROUND AT CULVERT	OTS	OAK TREES
GAP	GROUND AT PIER	PC	PECAN TREE
GAT	GATE	PCS	PECAN TREES
GGE	GAGE	PIC	PIPE INVERT, CONCRETE
GL	GAS LINE	PIM	PIPE INVERT, CMP
GM	GAS METER	PIN	PIPE INVERT
GRN	GROUND	PIP	PIPE INVERT, PLASTIC
GR	GUARD RAIL	PIR	PIER
GRV	GRAVEL	PIS	PIPE INVERT, STEEL
GTB	GAS TEST BOX	PL	PIPELINE CROSSING
GUY	GUY WIRE	PLC	POWER LINE CROSSING

Code	Definition
PLG	PILING
PLT	PLATFORM
POR	PORCH
PPE	PIPE
PPL	POWER POLE
PP	PICTURE POINT
PRK	PIPE RACK
PSC	PROTECTED SIDE CROWN
PST	PROTECTED SIDE TOE
PS	PROTECTED SIDE LEVEE
PT	10" PINE TREE
PTS	PINE TREES
PVC	PVC PIPE
PWC	4" POST WITH CABLE
PWL	POWERLINE
RAL	GUARD RAIL
RCK	ROCK
RCP	INV. RCP
RD	ROAD
RMP	RAMP
RDM	RED DAY MARKER
ROW	RIGHT OF WAY
RP	RIP RAP
RR	RAILROAD
RRP	RAILROAD POST
SCO	SEWER CLEAR OUT
SGN	SIGN
SGP	SIGN POST
SS	SOUTH SIDE
SHD	SHOULDER
SP	SHEET PILING
SHL	SHELL
SLP	SLOPE SHOT
SND	SOUNDINGS
SNG	SOUNDINGS
SOC	SLOPE ON CONCRETE
SRR	SLOPE ON RIP RAP
SPT	TOE OF SHEET PILING
SPV	SLOPE PAVING
STP	STEPS
SWK	SIDEWALK
TEP	TELEPHONE PEDESTAL
TB	TOE OF OLD RR BED
TBK	TOP OF BANK

Code	Definition
TBL	TOE OF BALLAST
TBP	TOP OF BORROW PIT
TBR	TOE OF BERM
TBS	TOP OF BALLAST
TC	TOP CONCRETE
TCB	TOP CONCRETE BANK
TCR	TOE CURB
TCS	TOP OF CONCRETE PAVEMENT (ON SLOPE)
TCW	TOP OF CONCRETE WALL
TEC	TOP ON EDGE OF CONCRETE WALL
TED	TOP EDGE OF DITCH
THR	THRESHOLD
TIP	3" POST
TNK	TANK
TOB	TOE OF BORROW PIT
TOC	TOE OF CONCRETE WALL
TOD	TOE OF DITCH
TOE	TOE ON NATURAL GROUND
TOL	TOP OF LEVEE
TOP	TOP ON NATURAL GROUND
TOR	TOE ROCK
TOW	TOP OF WALL
TPC	TOP CURB
TEL	TELEPHONE LINE
TP	TOP OF OLD RR BED
TPB	TOP OF BERM
TPL	TELEPHONE POLE
TPR	TOP ROCK
TPT	TOP SETTLEMENT PLATE
TPW	TOP OF CONCRETE WING WALL
TR	TREE
TRA	TOE OF GUARD RAIL
TRK	RR TRACK
TRL	TREE LINE
TRN	TRANSFORMER
TRW	TOE OF CONCRETE RETAINING WALL
TSP	TOP OF THE SHEET PILING
TWB	TOP WOOD BANK
TWR	TOWER
TWW	TOE OF CONCRETE WING WALL
UBX	UTILITY BOX
UGT	UNDERGROUND TELEPHONE LINE
UTL	UTILITIES
VAL	VALVE

Code	Definition
WF	WATER FAUCET
WLN	WATER LINE
WBT	WOOD BANK TOE
WBK	WOOD BULKHEAD
WDP	WOOD PILING
WE	WATER EDGE
WES	WATER EDGE SURFACE
WFL	WOOD FENCE LINE
WL	WOODLINE
WLK	WALKWAY
WLS	WILLOW TREES
WM	WATER MAIN - METER
WMA	WATER MAIN HOLE
WRW	WOODEN RETAINING WALL
WS	WATER SURFACE
WSB	WISTERA BUSH
WV	WATER VALVE
WW	WING WALL
XBR	BRIDGE CROSS BRACE

Table 13: Commonly-used feature codes

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