

APPENDIX I

Control Surveys: Bois Brule Levee and Drainage District (St. Louis District)

I-1. Purpose. This appendix provides an example of establishing primary NSRS control and supplemental local control on a levee segment along the Mississippi River. This example is typical of the survey procedures employed to establish NSRS control on any levee segment. This project was completed as part of the St. Louis District's effort in updating levee inventory information for inclusion in the National Levee Database (NLD). The database survey was performed by PBS&J—reference report "National Levee Foot Print Database Surveys," Contract W9133L-05-D-0003 DJ06, dated 19 May 2008.

I-2. Project Location. The Bois Brule Levee and Drainage District is located in northern Perry County, Missouri. The protected area is located on the right bank of the Mississippi River. The total length of flood protection is 38.84 miles long. This includes 38.7 miles of earthen levee (204,308.82 feet), 0.03 miles (146.52 feet) of floodwall, and 0.04 miles (190.99 feet) of closure structures. The protected area is roughly 26,350 acres.

I-3. Survey Control Methods Used to Connect Levees to the NSRS. GPS (RTK) survey methods were employed to establish control on various levee segments along the Mississippi River, as shown in Figure I-1. In the St. Louis area, a RTN network was used. North and south of the St. Louis RTN coverage (including the Bois Brule Levee District), standard RTK methods were employed. This involved recovering at least two published NSRS control points near the levee segment and using these points as a RTK base station. RTK checks between NSRS points were made to confirm the reliability of the NSRS points. Supplemental topographic surveys of levee features were made using RTK techniques.

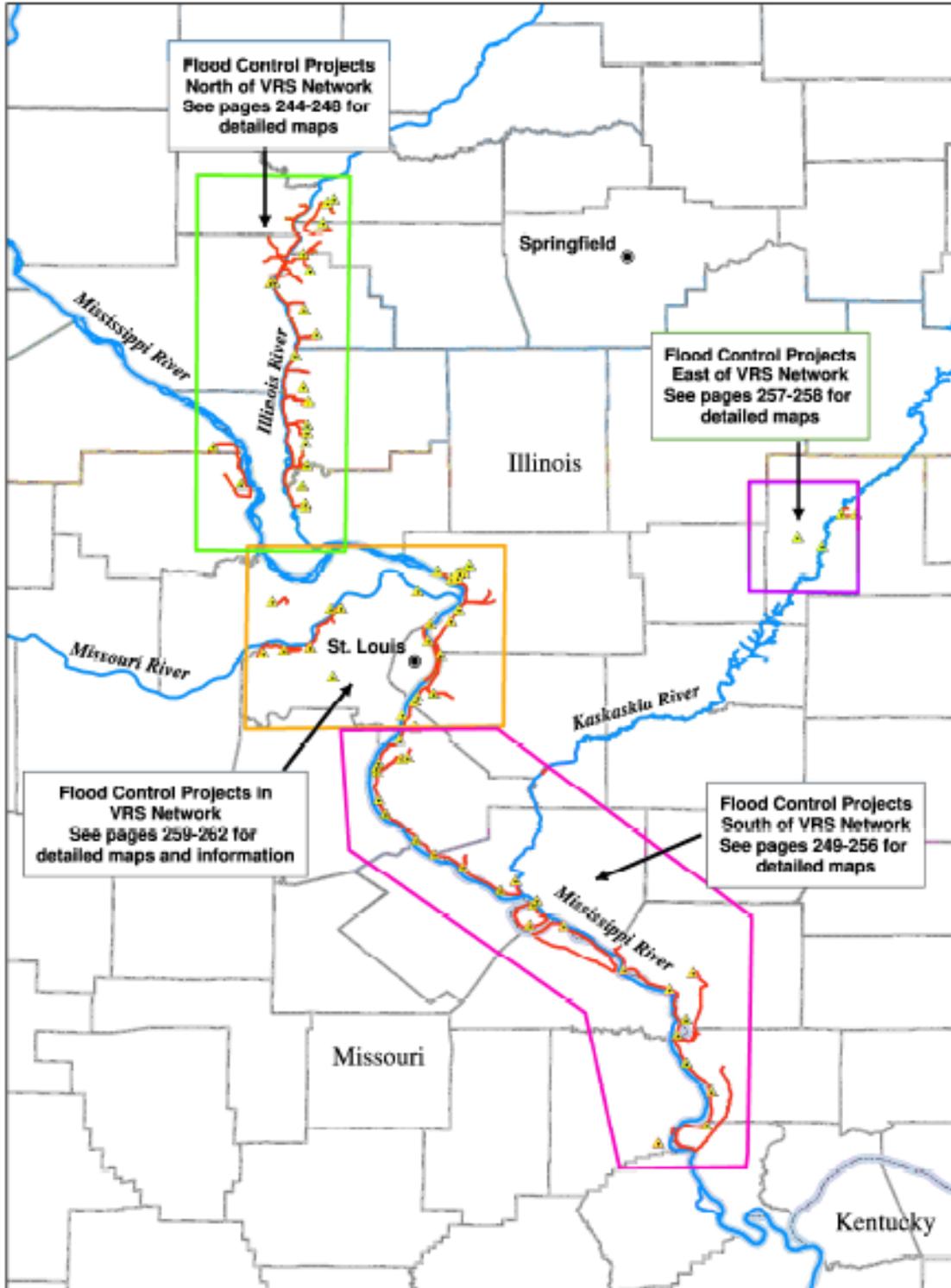


Figure I-1. Overview of survey control used to reference St. Louis District levees.

I-4. Bois Brule Primary Control Points. As shown on Figure I-2, two NSRS control bench marks were recovered in the vicinity of the Bois Brule Levee District—"R 323" (PID=HB1394) and "L 289" (PID=HB1377). These two NSRS points are approximately 10 miles apart. They were designated as PPCPs for this levee project. They are close enough to check internal RTK site calibration. Both points can be occupied with RTK base stations. NGS datasheets for these two points are at the end of this appendix.

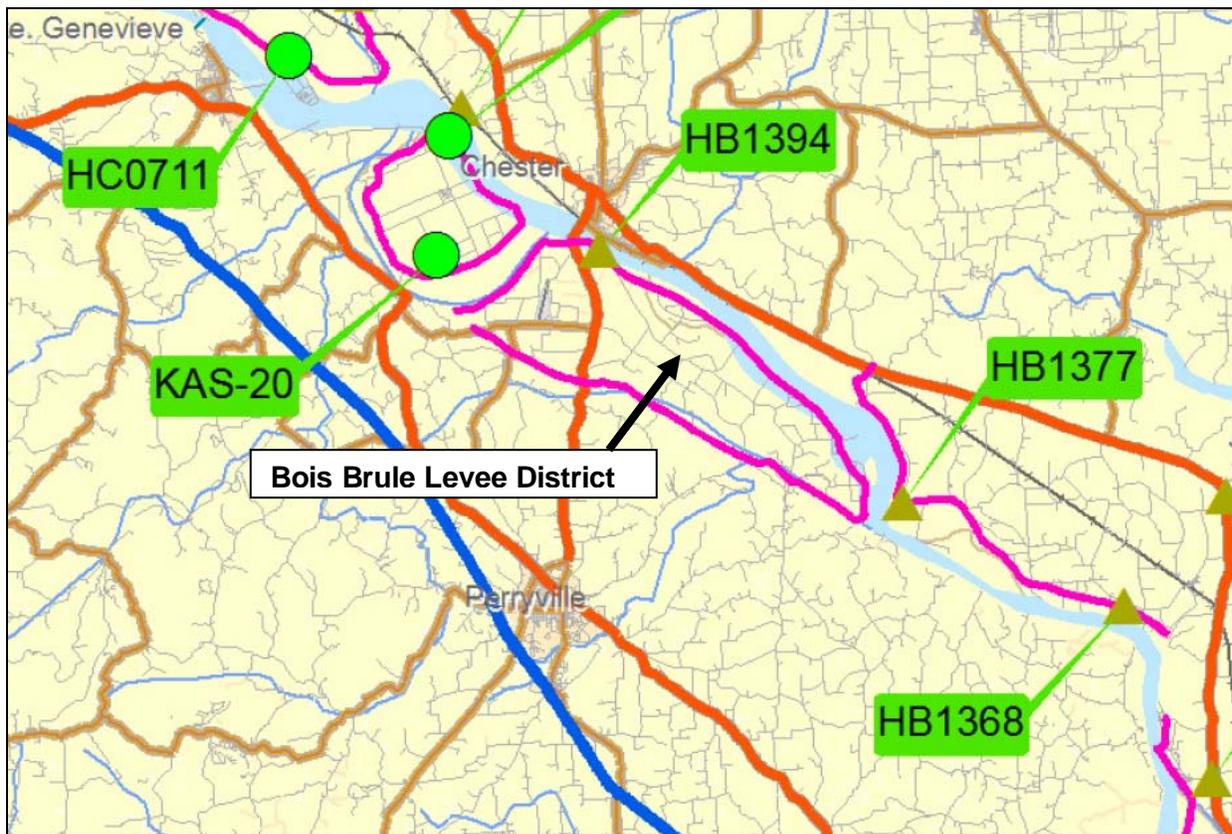


Figure I-2. NSRS control recovered vicinity of Bois Brule Levee District.

I-5. Survey Control / Data Collection. The following Figures I-3, I-4, and I-5 depict the primary NSRS control relative to the levee district boundary and the updated field station descriptions prepared for the NLD inventory report.

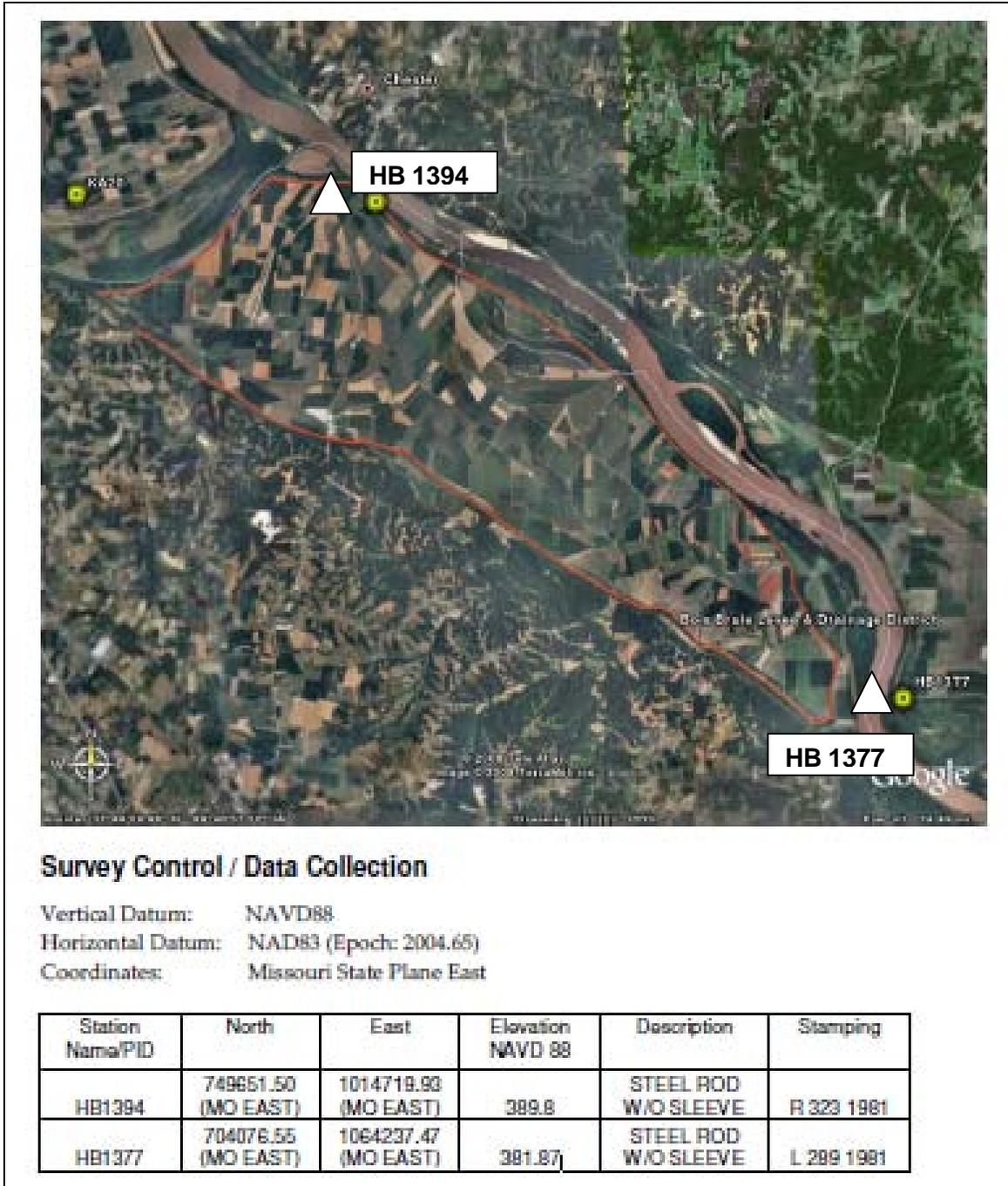


Figure I-3. NSRS control for PPCPs HB1394 and HB1377 (Bois Brule Levee District).

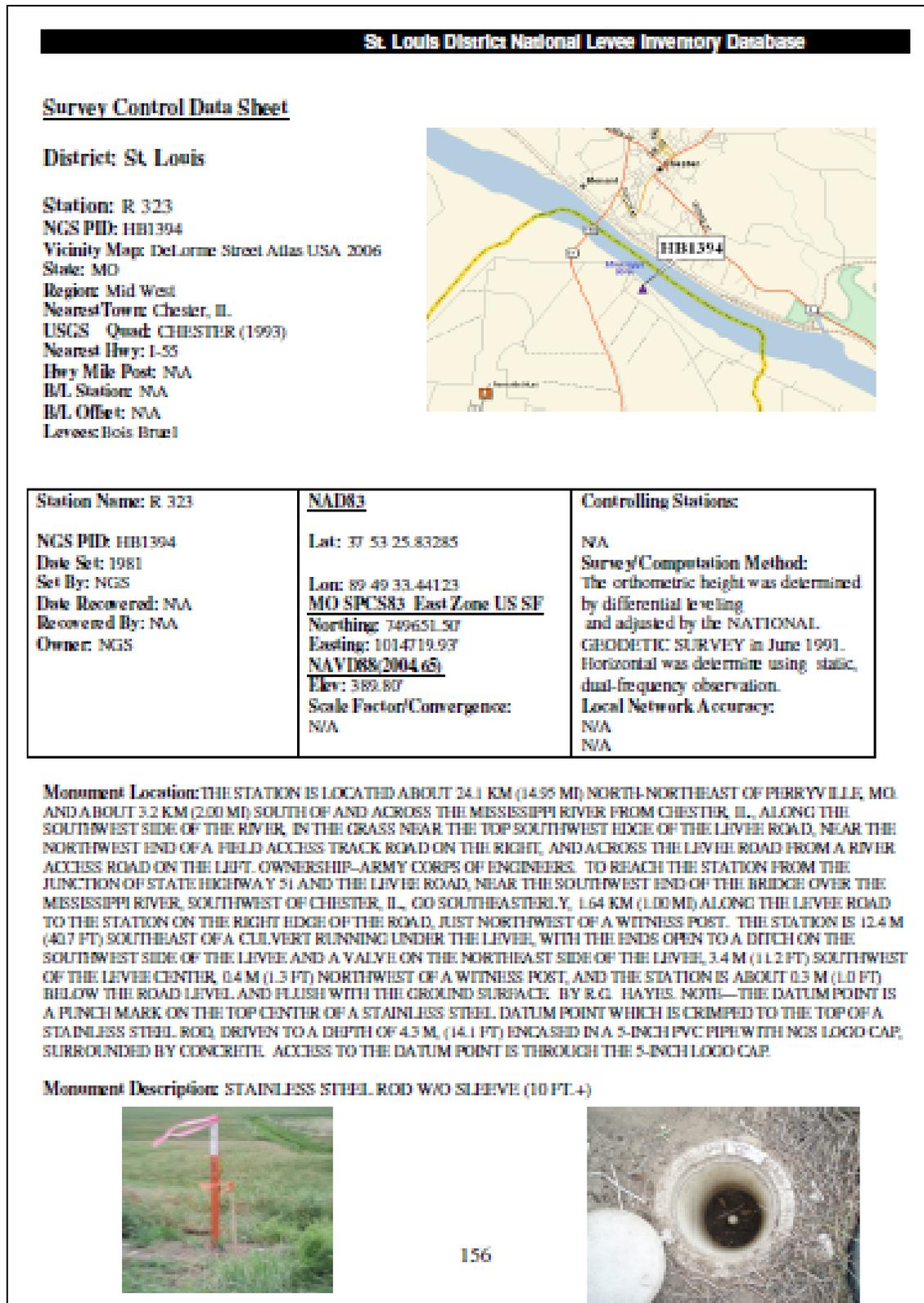


Figure I-4. Datasheet description for PBM "R 323" (HB1394) (Bois Brule Levee District).

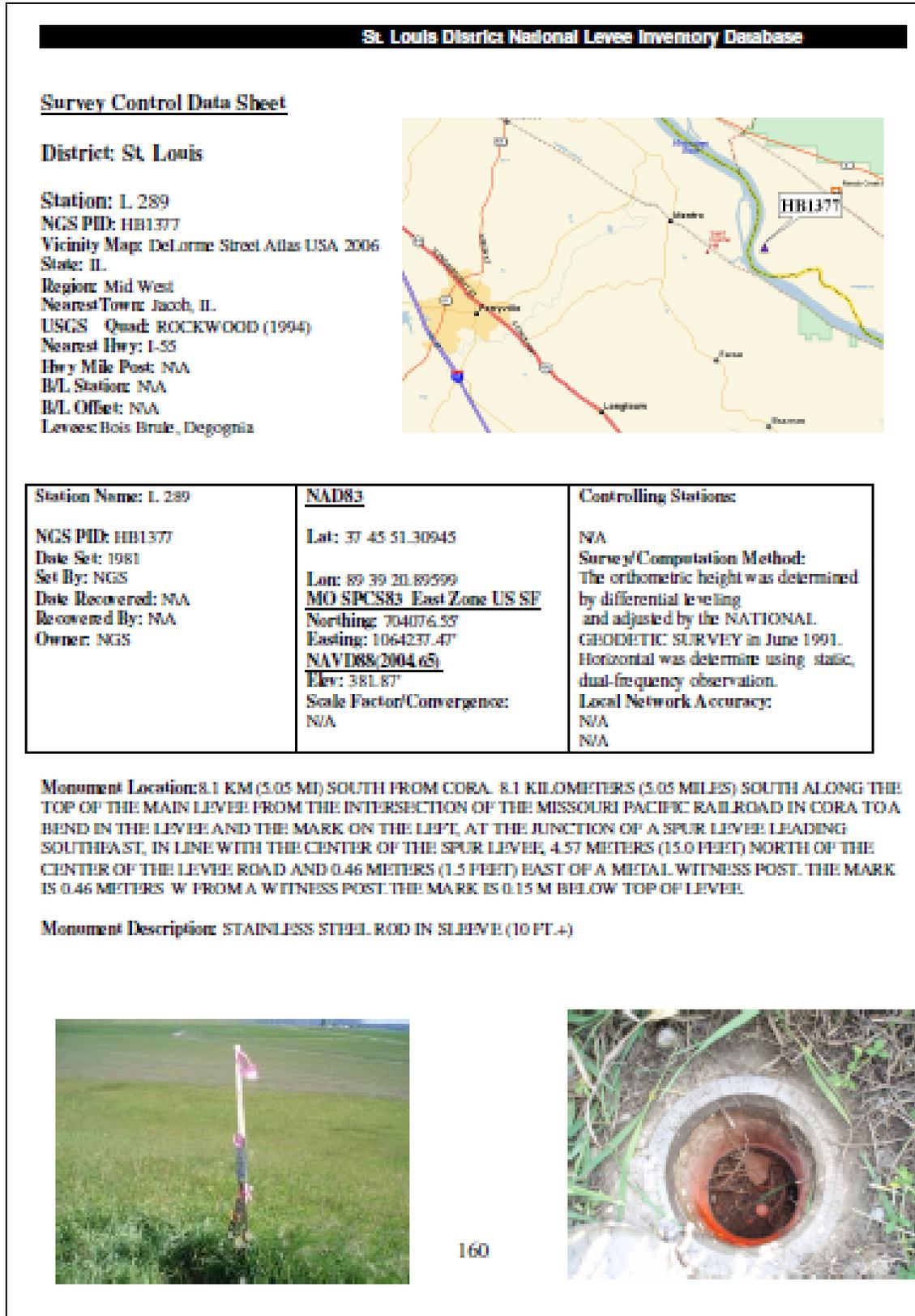


Figure I-5. Datasheet description for PBM "L 289" (HB1377) (Bois Brule Levee District).

I-6. Bois Brule Levee District Project Features Surveyed Relative to NSRS Primary Control Points HB1394 and HB1377. RTK feature and topographic surveys were performed relative to the PPCPs cited above. The top elevation of the levee varies from 381.94 to 395.09 feet with an average top width of 7.43 feet along the earthen levee sections. The features associated with the levee structure are listed below:

Boreholes: None Captured
Encroachment Points: 183
Flood Fight Points: None Captured
Crossing Points: 141
Failure Points: None Captured
Relief Wells: 427
Piezometers: 23
Pump Stations: 4
Sand Boils: None Captured
Closure Structure Count: 3
Cross Sections: 29
Floodwall Lines: 4
Gravity Drains: 26
Rehab Lines: None Captured
Toe Drains: None Captured

The twenty-nine cross-sections were taken along the levee at stations 8+07, 75+34, 150+98, 182+25, 237+31, 313+64, 371+80, 436+29, 493+32, 575+88, 637+63, 704+83, 790+03, 832+25, 880+66, 920+53, 971+90, 1037+63, 1103+81, 1144+14, 1208+87, 1272+00, 1336+40, 1388+08, 1476+63, 1541+14, 1581+70, 1640+48, and 1725+92.

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I-7. Use of RTN Networks for Referencing Levee Control. Figure I-6 depicts RTN network coverage in the St. Louis region. Levee control and NLD inventory points can be directly surveyed from such an RTN network. Prior to performing supplemental surveys, the RTN network is calibrated against existing NSRS control in the vicinity of the levee—as highlighted in green in Figure I-6. Figures I-7 and I-8 show the results of the RTN calibration checks at selected NSRS points. These results indicate vertical checks are within ± 0.25 ft tolerances. The calibration differences at NSRS "tie points" should be applied to local observations—i.e., "site calibration."

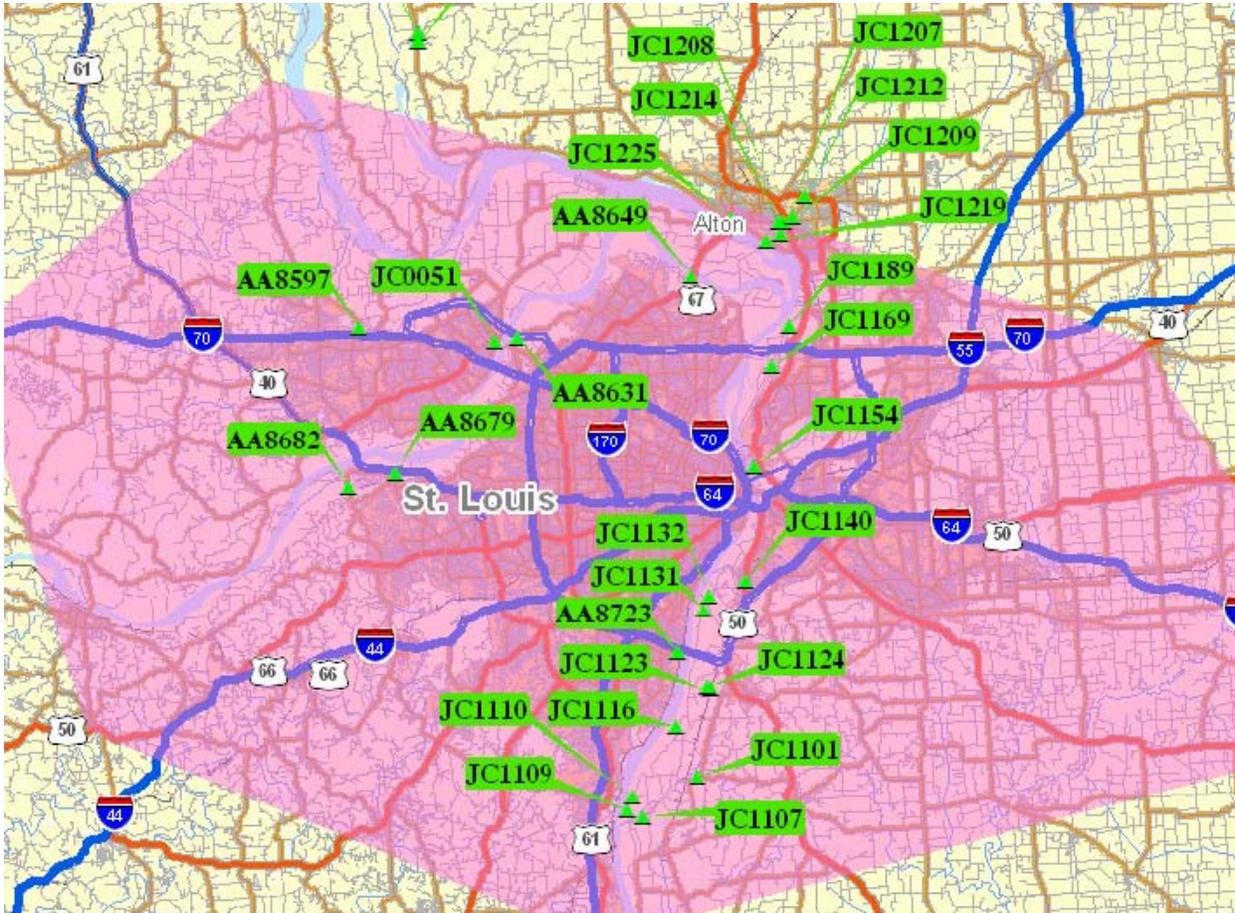


Figure I-6. RTN coverage in the St. Louis region and NSRS check points.

VRS BASE STATION	NGS STATION	DISTRICTS USED IN
SRDX	DI2212	Monarch Chesterfield
SIAI	(No PID)	Metro East, Chain of Rocks, Wood River
SIHQ	DH7921	Metro East, Chain or Rocks, Prairie DuPont, Columbia
WIFH	DI2210	Metro East, Chain of RocksPrairie DuPont
TWMW	DI2208	Prairie DuPont, Columbia, Fish Lake
FWIF	(No PID)	Nutwood, Eldred,Spankey

Figure I-7. RTN (VRS) site calibration points for various levee segments in St. Louis area.

RMS TABLE							
PROJECT:	Midwest RTK Network RMS Check						
DATE:	April 30, 2007						
TIE POINT	N	E	Z	REF(BM)	N	E	Z
AA8597	1083358.929	777759.266	528.897	AA8597	1083358.936	777759.200	529.0
AA8631	1076448.529	833046.498	458.900	AA8631	1076448.429	833046.410	459
AA8649	1094248.925	894738.346	486.682	AA8649	1094248.849	894738.276	487
AA8723	965171.227	882610.836	416.358	AA8723	965171.290	882610.656	416.4
JC0051			527.494	JC0051			527.73
JC1107			413.786	JC1107			413.99
JC1132			426.435	JC1132			426.32
JC1212 (O/S)			468.830	JC1212 (O/S)			468.93
JC1225 (O/S)			554.390	JC1225 (O/S)			554.52
HORIZ.RMS =		0.13					
VERT.RMS =		0.17					

Figure I-8. RTN (VRS) site calibration "Published – Observed" differences.

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I-8. NGS Data Sheet for R 323 (PID HB1394).

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HB1394 *****
HB1394 FBN - This is a Federal Base Network Control Station.
HB1394 DESIGNATION - R 323
HB1394 PID - HB1394
HB1394 STATE/COUNTY- MO/PERRY
HB1394 USGS QUAD - CHESTER (1993)
HB1394
HB1394 *CURRENT SURVEY CONTROL
HB1394
-----
HB1394* NAD 83(2007)- 37 53 25.83293(N) 089 49 33.44072(W) ADJUSTED
HB1394* NAVD 88 - 118.811 (meters) 389.80 (feet) ADJUSTED
HB1394
-----
HB1394 EPOCH DATE - 2002.00
HB1394 X - 15,309.625 (meters) COMP
HB1394 Y - -5,039,949.530 (meters) COMP
HB1394 Z - 3,895,914.999 (meters) COMP
HB1394 LAPLACE CORR- 0.93 (seconds) USDV2009
HB1394 ELLIP HEIGHT- 89.321 (meters) (02/10/07) ADJUSTED
HB1394 GEOID HEIGHT- -29.48 (meters) GEOID09
HB1394 DYNAMIC HT - 118.730 (meters) 389.53 (feet) COMP
HB1394
HB1394 ----- Accuracy Estimates (at 95% Confidence Level in cm) -----
HB1394 Type PID Designation North East Ellip
HB1394 -----
HB1394 NETWORK HB1394 R 323 0.41 0.31 1.12
HB1394 -----
HB1394 MODELED GRAV- 979,943.3 (mgal) NAVD 88
HB1394
HB1394 VERT ORDER - FIRST CLASS II
HB1394
HB1394.The horizontal coordinates were established by GPS observations
HB1394.and adjusted by the National Geodetic Survey in February 2007.
HB1394
HB1394.The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
HB1394.See National Readjustment for more information.
HB1394.The horizontal coordinates are valid at the epoch date displayed above.
HB1394.The epoch date for horizontal control is a decimal equivalence
HB1394.of Year/Month/Day.
HB1394
HB1394.The orthometric height was determined by differential leveling
HB1394.and adjusted in June 1991.
HB1394
HB1394.The X, Y, and Z were computed from the position and the ellipsoidal ht.
HB1394
HB1394.The Laplace correction was computed from USDV2009 derived deflections.
HB1394
HB1394.The ellipsoidal height was determined by GPS observations
HB1394.and is referenced to NAD 83.
HB1394
HB1394.The geoid height was determined by GEOID09.
HB1394
HB1394.The dynamic height is computed by dividing the NAVD 88
HB1394.geopotential number by the normal gravity value computed on the
HB1394.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
HB1394.degrees latitude (g = 980.6199 gals.).
HB1394
HB1394.The modeled gravity was interpolated from observed gravity values.
HB1394
HB1394;
HB1394; North East Units Scale Factor Converg.
HB1394;SPC MO E - 228,494.237 309,287.266 MT 0.99997661 +0 24 50.3
HB1394;UTM 16 - 4,197,432.411 251,495.217 MT 1.00036068 -1 44 11.3

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HB1394
 HB1394! - Elev Factor x Scale Factor = Combined Factor
 HB1394!SPC MO E - 0.99998598 x 0.99997661 = 0.99996259
 HB1394!UTM 16 - 0.99998598 x 1.00036068 = 1.00034666
 HB1394
 HB1394 SUPERSEDED SURVEY CONTROL
 HB1394
 HB1394 ELLIP H (02/11/04) 89.315 (m) GP() 4 1
 HB1394 NAD 83(1997)- 37 53 25.83260(N) 089 49 33.44129(W) AD() B
 HB1394 ELLIP H (03/31/98) 89.326 (m) GP() 3 1
 HB1394 NAVD 88 (03/31/98) 118.81 (m) 389.8 (f) LEVELING 3
 HB1394 NGVD 29 (??/??/??) 118.742 (m) 389.57 (f) ADJUSTED 1 2
 HB1394

HB1394.Superseded values are not recommended for survey control.
 HB1394.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 HB1394.[See file dsdata.txt](#) to determine how the superseded data were derived.
 HB1394

HB1394_U.S. NATIONAL GRID SPATIAL ADDRESS: 16SBG5149597432(NAD 83)
 HB1394_MARKER: I = METAL ROD
 HB1394_SETTING: 49 = STAINLESS STEEL ROD W/O SLEEVE (10 FT.+)
 HB1394_SP_SET: STAINLESS STEEL ROD
 HB1394_STAMPING: R 323 1981
 HB1394_MARK LOGO: NGS
 HB1394_PROJECTION: FLUSH
 HB1394_MAGNETIC: N = NO MAGNETIC MATERIAL
 HB1394_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
 HB1394_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
 HB1394+SATELLITE: SATELLITE OBSERVATIONS - October 05, 2009
 HB1394_ROD/PIPE-DEPTH: 4.30 meters
 HB1394

HB1394 HISTORY	- Date	Condition	Report By
HB1394 HISTORY	- 1981	MONUMENTED	NGS
HB1394 HISTORY	- 19970226	GOOD	NGS
HB1394 HISTORY	- 19970626	GOOD	NGS
HB1394 HISTORY	- 19990830	GOOD	NGS
HB1394 HISTORY	- 20030724	GOOD	MODNR
HB1394 HISTORY	- 20030804	GOOD	MODNR
HB1394 HISTORY	- 20050315	GOOD	MODNR
HB1394 HISTORY	- 20091005	GOOD	MODNR

HB1394
 HB1394 STATION DESCRIPTION
 HB1394
 HB1394'DESCRIBED BY NATIONAL GEODETIC SURVEY 1981
 HB1394'2.95 KM (1.85 MI) SOUTH FROM CHESTER.
 HB1394'1.35 KILOMETERS (0.85 MILE) SOUTHWEST ALONG ILLINOIS STATE HIGHWAY 150
 HB1394'AND MISSOURI STATE HIGHWAY 51 FROM THE JUNCTION REILY ROAD AND THE
 HB1394'TOLL BOOTH OF THE BRIDGE IN CHESTER, THENCE 1.6 KILOMETERS (1.0 MILE)
 HB1394'SOUTHEAST ALONG THE TOP OF THE MAIN LEVEE TO THE MARK ON THE RIGHT,
 HB1394'4.42 METERS (14.5 FEET) SOUTHWEST OF THE CENTER OF THE LEVEE ROAD AND
 HB1394'0.46 METER (1.5 FEET) SOUTHEAST OF A METAL WITNESS POST.
 HB1394'THE MARK IS 0.46 METERS NW FROM A WITNESS POST.
 HB1394'THE MARK IS ABOVE LEVEL WITH TOP OF LEVEE.
 HB1394

HB1394
 HB1394 STATION RECOVERY (1997)
 HB1394
 HB1394'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1997 (CSM)
 HB1394'THE STATION IS LOCATED ABOUT 24.1 KM (14.95 MI) NORTH-NORTHEAST OF
 HB1394'PERRYVILLE, MO. AND ABOUT 3.2 KM (2.00 MI) SOUTH OF AND ACROSS THE
 HB1394'MISSISSIPPI RIVER FROM CHESTER, IL., ALONG THE SOUTHWEST SIDE OF THE
 HB1394'RIVER, IN THE GRASS NEAR THE TOP SOUTHWEST EDGE OF THE LEVEE ROAD,
 HB1394'NEAR THE NORTHWEST END OF A FIELD ACCESS TRACK ROAD ON THE RIGHT, AND
 HB1394'ACROSS THE LEVEE ROAD FROM A RIVER ACCESS ROAD ON THE LEFT.
 HB1394'OWNERSHIP--ARMY CORPS OF ENGINEERS. TO REACH THE STATION FROM THE

EM 1110-2-6056

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HB1394' JUNCTION OF STATE HIGHWAY 51 AND THE LEVEE ROAD, NEAR THE SOUTHWEST
HB1394' END OF THE BRIDGE OVER THE MISSISSIPPI RIVER, SOUTHWEST OF CHESTER,
HB1394' IL., GO SOUTHEASTERLY, 1.64 KM (1.00 MI) ALONG THE LEVEE ROAD TO THE
HB1394' STATION ON THE RIGHT EDGE OF THE ROAD, JUST NORTHWEST OF A WITNESS
HB1394' POST. THE STATION IS 12.4 M (40.7 FT) SOUTHEAST OF A CULVERT RUNNING
HB1394' UNDER THE LEVEE, WITH THE ENDS OPEN TO A DITCH ON THE SOUTHWEST SIDE
HB1394' OF THE LEVEE AND A VALVE ON THE NORTHEAST SIDE OF THE LEVEE, 3.4 M
HB1394' (11.2 FT) SOUTHWEST OF THE LEVEE CENTER, 0.4 M (1.3 FT) NORTHWEST OF A
HB1394' WITNESS POST, AND THE STATION IS ABOUT 0.3 M (1.0 FT) BELOW THE ROAD
HB1394' LEVEL AND FLUSH WITH THE GROUND SURFACE. BY R.G. HAYES. NOTE--THE
HB1394' DATUM POINT IS A PUNCH MARK ON THE TOP CENTER OF A STAINLESS STEEL
HB1394' DATUM POINT WHICH IS CRIMPED TO THE TOP OF A STAINLESS STEEL ROD,
HB1394' DRIVEN TO A DEPTH OF 4.3 M, (14.1 FT) ENCASED IN A 5-INCH PVC PIPE
HB1394' WITH NGS LOGO CAP, SURROUNDED BY CONCRETE. ACCESS TO THE DATUM POINT
HB1394' IS THROUGH THE 5-INCH LOGO CAP.

HB1394

STATION RECOVERY (1997)

HB1394

HB1394' RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1997 (CSM)

HB1394' RECOVERED AS DESCRIBED.

HB1394

STATION RECOVERY (1999)

HB1394

HB1394' RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 1999 (RB)

HB1394' RECOVERED AS DESCRIBED

HB1394'

HB1394

STATION RECOVERY (2003)

HB1394

HB1394' RECOVERY NOTE BY MO DEPT OF NAT RES 2003 (WW)

HB1394' RECOVERED AS DESCRIBED.

HB1394

STATION RECOVERY (2003)

HB1394

HB1394' RECOVERY NOTE BY MO DEPT OF NAT RES 2003 (BDC)

HB1394' RECOVERED IN GOOD CONDITION.

HB1394

STATION RECOVERY (2005)

HB1394

HB1394' RECOVERY NOTE BY MO DEPT OF NAT RES 2005 (MJC)

HB1394' RECOVERED AS DESCRIBED. DESCRIPTION AND TO REACH ARE ADEQUATE.

HB1394

STATION RECOVERY (2009)

HB1394

HB1394' RECOVERY NOTE BY MO DEPT OF NAT RES 2009 (MJC)

HB1394'

HB1394' THE STATION IS LOCATED IN T37N R11E, IN USS 440.

HB1394'

HB1394' IT IS 11 FT. SW OF THE CENTER OF LEVEE ROAD, 92.2 FT. WNW OF THE NORTH

HB1394' I-BEAM GATE POST, 95.1 FT. NW OF THE SOUTH I-BEAM GATE POST AND 1.0

HB1394' FT. NW OF A CARSONITE WITNESS POST.

HB1394'

I-9. NGS Data Sheet for L 289 (PID HB1377).

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HB1377 *****
HB1377 CBN - This is a Cooperative Base Network Control Station.
HB1377 DESIGNATION - L 289
HB1377 PID - HB1377
HB1377 STATE/COUNTY- IL/JACKSON
HB1377 USGS QUAD - ROCKWOOD (1994)
HB1377
HB1377 *CURRENT SURVEY CONTROL
HB1377
-----
HB1377* NAD 83(2007)- 37 45 51.31029(N) 089 39 20.89642(W) ADJUSTED
HB1377* NAVD 88 - 116.393 (meters) 381.87 (feet) ADJUSTED
HB1377
-----
HB1377 EPOCH DATE - 2002.00
HB1377 X - 30,328.286 (meters) COMP
HB1377 Y - -5,048,474.489 (meters) COMP
HB1377 Z - 3,884,844.775 (meters) COMP
HB1377 LAPLACE CORR- -0.37 (seconds) USDV2009
HB1377 ELLIP HEIGHT- 87.252 (meters) (02/10/07) ADJUSTED
HB1377 GEOID HEIGHT- -29.16 (meters) GEOID09
HB1377 DYNAMIC HT - 116.313 (meters) 381.60 (feet) COMP
HB1377
HB1377 ----- Accuracy Estimates (at 95% Confidence Level in cm) -----
HB1377 Type PID Designation North East Ellip
HB1377 -----
HB1377 NETWORK HB1377 L 289 1.20 0.73 1.98
HB1377 -----
HB1377 MODELED GRAV- 979,933.4 (mgal) NAVD 88
HB1377
HB1377 VERT ORDER - FIRST CLASS II
HB1377
HB1377.The horizontal coordinates were established by GPS observations
HB1377.and adjusted by the National Geodetic Survey in February 2007.
HB1377
HB1377.The datum tag of NAD 83(2007) is equivalent to NAD 83(NSRS2007).
HB1377.See National Readjustment for more information.
HB1377.The horizontal coordinates are valid at the epoch date displayed above.
HB1377.The epoch date for horizontal control is a decimal equivalence
HB1377.of Year/Month/Day.
HB1377
HB1377.The orthometric height was determined by differential leveling
HB1377.and adjusted in June 1991.
HB1377
HB1377.The X, Y, and Z were computed from the position and the ellipsoidal ht.
HB1377
HB1377.The Laplace correction was computed from USDV2009 derived deflections.
HB1377
HB1377.The ellipsoidal height was determined by GPS observations
HB1377.and is referenced to NAD 83.
HB1377
HB1377.The geoid height was determined by GEOID09.
HB1377
HB1377.The dynamic height is computed by dividing the NAVD 88
HB1377.geopotential number by the normal gravity value computed on the
HB1377.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
HB1377.degrees latitude (g = 980.6199 gals.).
HB1377
HB1377.The modeled gravity was interpolated from observed gravity values.
HB1377
HB1377;
HB1377;SPC IL W - North East Units Scale Factor Converg.
121,927.701 745,011.038 MT 0.99996612 +0 18 46.3

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EM 1110-2-6056

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HB1377;SPC IL W - 400,024.47 2,444,257.05 sFT 0.99996612 +0 18 46.3
HB1377;UTM 16 - 4,182,980.653 266,061.861 MT 1.00027412 -1 37 37.9

HB1377

HB1377! - Elev Factor x Scale Factor = Combined Factor

HB1377!SPC IL W - 0.99998631 x 0.99996612 = 0.99995243

HB1377!UTM 16 - 0.99998631 x 1.00027412 = 1.00026042

HB1377

HB1377 SUPERSEDED SURVEY CONTROL

HB1377

HB1377 NAD 83(1997)- 37 45 51.31026(N) 089 39 20.89637(W) AD() A

HB1377 ELLIP H (09/15/03) 87.253 (m) GP() 4 1

HB1377 NGVD 29 (??/??/??) 116.316 (m) 381.61 (f) ADJUSTED 1 2

HB1377

HB1377.Superseded values are not recommended for survey control.

HB1377.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.

HB1377.[See file dsdata.txt](#) to determine how the superseded data were derived.

HB1377

HB1377_U.S. NATIONAL GRID SPATIAL ADDRESS: 16SBG6606182980(NAD 83)

HB1377_MARKER: I = METAL ROD

HB1377_SETTING: 59 = STAINLESS STEEL ROD IN SLEEVE (10 FT.+)

HB1377_SP_SET: STAINLESS STEEL ROD IN SLEEVE

HB1377_STAMPING: L 289 1981

HB1377_MARK LOGO: NGS

HB1377_PROJECTION: FLUSH

HB1377_MAGNETIC: N = NO MAGNETIC MATERIAL

HB1377_STABILITY: A = MOST RELIABLE AND EXPECTED TO HOLD

HB1377+STABILITY: POSITION/ELEVATION WELL

HB1377_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR

HB1377+SATELLITE: SATELLITE OBSERVATIONS - March 08, 2006

HB1377_ROD/PIPE-DEPTH: 21.9 meters

HB1377_SLEEVE-DEPTH : 6.10 meters

HB1377

HB1377 HISTORY - Date Condition Report By

HB1377 HISTORY - 1981 MONUMENTED NGS

HB1377 HISTORY - 20020805 GOOD NGS

HB1377 HISTORY - 20060308 GOOD ILDT

HB1377

HB1377 STATION DESCRIPTION

HB1377

HB1377'DESCRIBED BY NATIONAL GEODETIC SURVEY 1981

HB1377'8.1 KM (5.05 MI) SOUTH FROM CORA.

HB1377'8.1 KILOMETERS (5.05 MILES) SOUTH ALONG THE TOP OF THE MAIN LEVEE FROM

HB1377'THE INTERSECTION OF THE MISSOURI PACIFIC RAILROAD IN CORA TO A BEND IN

HB1377'THE LEVEE AND THE MARK ON THE LEFT, AT THE JUNCTION OF A SPUR LEVEE

HB1377'LEADING SOUTHEAST, IN LINE WITH THE CENTER OF THE SPUR LEVEE,

HB1377'4.57 METERS (15.0 FEET) NORTH OF THE CENTER OF THE LEVEE ROAD AND

HB1377'0.46 METERS (1.5 FEET) EAST OF A METAL WITNESS POST.

HB1377'THE MARK IS 0.46 METERS W FROM A WITNESS POST.

HB1377'THE MARK IS 0.15 M BELOW TOP OF LEVEE.

HB1377

HB1377 STATION RECOVERY (2002)

HB1377

HB1377'RECOVERY NOTE BY NATIONAL GEODETIC SURVEY 2002 (BE)

HB1377'RECOVERED AS DESCRIBED

HB1377'

HB1377'

HB1377

HB1377