CITY OF FIFE

VERTICAL BENCHMARKS ADDENDUM HORIZONTAL CONTROL

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Prepared by AHR Engineers, Inc.

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CITY OF FIFE

2003 BENCH MARK PROGRAM

AHR ENGINEERS

Executive Summary:

The 2003 bench mark program was undertaken to replace or update the numerous city bench marks that had been disturbed or destroyed since the last bench mark program in 1989.

In 1989, AHR survey crews set bench marks in the conventional manner, using differential levels based on existing official bench marks that had been set by the City of Tacoma, Pierce County, and the U.S. Geodetic Survey branch of the Interior Department. AHR set 50 benchmarks in that program. By January, 2003, 80% had been destroyed or disturbed.

In the past few years, GPS (Global Positioning System) technology has become available that makes large-scale surveying much faster and more accurate than it was in 1989. Using GPS satellites and a GPS receiver in RTK (Real-time Kinetic) or static mode, it is now possible to locate a point within 0.033 feet horizontally and 0.033 feet vertically in RTK mode with proper satellite and control conditions.

Pierce County has been the local leader in utilizing GPS technology in its survey control system. To establish the backbone of its control system, Pierce County used the GPS satellites and a base station mounted on the Emergency Services tower at the Pierce County Annex. The County mounted the base station at the highest convenient location to provide as much coverage as possible around the county.

In the Fife area, Pierce County has established numerous control monuments. Some are vertical control set by differential levels. A few are GPS monuments that have horizontal and vertical control and some that have horizontal control only. After discussions with the Pierce County office surveyor, AHR selected five of these monuments for the basis of our control. They were:

County Point #	Description
089	Small domed brassie. Quarter corner 16th Street East – 62nd Avenue East center of intersection. Horizontal and vertical Control (FN-22).

494	Pierce County Standard brassie section corner 12-7-13-18 300 feet east of Pacific Highway East and 20 feet west of driveway 3726 Pacific Highway East. Horizontal control (FN-7)
161-7	Pierce County Standard bench mark brassie in island, 35 feet east of centerline 70th Avenue East and 20 feet north of centerline of North Levee Road East. Vertical control (FS-32).
161-9	Pierce County Standard bench mark brassie in asphalt 15 feet east of centerline drive to residence 6215 North Levee Road East, 12 feet north of centerline North Levee Road East. Vertical control (FS-39)
163-2	Top 2" brassie south side asphalt drive to Fife Fire and Rescue Firwood Station, 20 feet east of front entrance on west side of 4500 block of Freeman Road. Vertical control (FS-36)

Pierce County used their GPS system in static mode to establish the horizontal position of the monuments in Washington State Plane coordinates, and the elevation by the 1929 National Geodetic Vertical Datum (NGVD). In static mode, the GPS remote unit is set up over the monument and left to receive signals from the satellites and the base station for about half an hour, receiving signals at the rate of one per second. At the end of the half hour, the approximately 1,800 readings processed and produced a set of coordinates for that point with an accuracy of within 0.164 feet horizontally and 0.033 feet vertically based on the conditions of the satellites and control. It should be noted that RTK and static produce different accuracies as well as the quality of control that can affect accuracy. The geometry of control surrounding a project area can impact results as well.

AHR Engineers then used the five Pierce County monuments and their own GPS unit, a new Ashtech Model Z-Xtreme, to set up a geoid model. The capabilities of the Ashtech model are listed as follows: RTK mode: Horizontal <1 cm (0.033ft). Vertical <1 cm (0.033 ft). Static mode: Horizontal <5 mm (0.015 ft). Vertical <5 mm (0.015 ft). Then results are possible with proper control, network design and satellites conditions. The model is a mathematical representation of the Earth's surface in Fife, and allows coordinates of any point within the model to be computed by the remote unit within a few seconds.

Setting up the model was the most difficult part of the bench mark program. The difficulty was caused by the multiplicity of elevation bench marks previously used around Fife. These included Pierce County GPS elevations based on the 1929 NGVD, Pierce County differential level (conventional) elevations, City of Tacoma bench marks, U.S.G.S. bench marks, FEMA maps, WSDOT bench marks, and the remaining 1989 Fife bench marks, which were set using a U.S.G.S. bench mark in Tacoma that was later destroyed.

After a number of failed attempts to create a realistic and consistent model, AHR discovered that trying to utilize the different published bench marks would only introduce errors into the vertical aspect of the model, and that the different datums would never be reconciled.

To make the model more realistic, AHR used only the recent Pierce County GPS elevations. When the model was calibrated for that datum alone, the results became much more consistent

and accurate. Consequently, all the new bench marks are based on the Pierce County GPS datum, the 1929 NGVD.

AHR noted that a difference existed between the Pierce County 1929 NGVD elevation datum and the City of Tacoma (old City of Fife) datum. The Pierce County datum is about 0.3 foot lower than City of Tacoma (Fife). AHR gathered this data by visiting 7 to 8 City of Tacoma and USGS published monuments around Fife perimeter to check for vertical consistency. The difference was almost uniformly 0.3 feet, which was later verified in a telephone conversation with the Pierce County office surveyor. For example, the USGS bench mark on the Highway 99 bridge over Hylebos Creek was 0.3 higher than the Pierce County datum.

Once a reliable model was created, AHR could determine the coordinates of points using the GPS RTK mode. In RTK mode, the GPS remote unit is placed on a point and the coordinates are determined in less than 30 seconds, rather than the lengthy waits required in static mode. The bench mark shots were all reshot two or more times to insure accuracy within the unit's capability.

The speed and accuracy of RTK measurements depend on the number of satellites available and related control conditions at the time. Daily "windows" of optimum satellite coverage constantly changes and requires advance scheduling for timing in the field. In general, a minimum of five to six satellites is required, which will allow coordinates to be calculated in about 15 seconds. When more satellites are available, the time required to calculate decreases. With eight satellites, the time required is usually less than five seconds.

GPS reception may also be affected by power lines, trees, tall buildings, power/light poles or large advertising signs which can interfere with radio signals. These items were encountered at various benchmarks and the shots were rechecked to achieve the desired range of accuracy.

Each new bench mark listing has an elevation on Pierce County 1929 NGVD, as well as horizontal coordinates tied to Pierce County control, unlike previous bench mark systems. AHR has provided the horizontal coordinates (on Washington State Plane Grid South, the same as Pierce County) to assist the City of Fife for future mapping requirements on the Pierce County GIS systems. AHR did not provide points to be used for horizontal reference in lieu of the Pierce County control points already established for reference on future surveying projects.

Like the Pierce County GPS control system upon which it is based, Fife's new bench marks are expected to be within the same 0.16 feet horizontally and 0.033 feet vertically. All 60 of the new bench marks have been shot at least twice, and some as many as five times. The reason for multiple shots is to verify that the separate readings are consistent and accurate. The consistency was expected to be within 0.033 feet. The published elevation is the average of those measurements.

The location of each new bench mark is described in the text, along with the elevation, horizontal coordinates, a description of the mark itself, and a photograph. Following standard practice for long projects that may need two bench marks, a conventional level loop should be run between the benches to establish a project datum.

AHR anticipates the new bench marks will provide the City of Fife with a vertical control system that will allow public and private projects to be built with certainty they will fit into the City's stormwater and sanitary sewage system. In addition, the new system can be readily adapted to a control system for a future aerial topographic mapping program for the City.

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Point	Ref #	Northing	Easting	Elev	Short Desc	Long Desc
1	FN-1	702377.0658	1168258.5950	9.60	b/m fn1	Top of brass monument center of Milwaukee Road at 2320 Milwaukee Way. Entrance to Associated Petroleum Products.
2	FN-2	702205.0510	1169694.0300	8.32	spike fn2	Railroad spike at end of concrete curb, west side of east entrance drive to 2519 Pacific Highway East (Old 99), 13 feet north of back of sidewalk.
3	FN-3	702039.2200	1170967.9510	9.96	spike fn3	Railroad spike east side of east drive to 2820 Pacific Highway East (Old 99), adjacent to curb, 2.5 feet south of light pole base.
4	FN-4	702241.6810	1172135.0288	10.79	x fn4	Railroad spike at end of curb northeast entrance off Port of Tacoma Road to 3251 Pacific Highway East (Old 99). Approximately 35 feet north of concrete Port of Tacoma sign.
5	FN-5	703025.1510	1172627.1552	10.35	x fn5	"X" on southeast corner phone vault at southwest corner of 34th Avenue East and truck ramp to Port of Tacoma Road.
6	FN-6	701971.0430	1173069.5400	10.52	x fn6	"X" top of curb northeast corner parking lot 3410 Pacific Highway East (Old 99). Freddie's Casino.
7	FN-7	701841.9100	1173928.4420	13.94	b/m fn7	Brass section corner monument for sections 1, 2, 11, 12. 130 feet south of Pacific Highway East (Old 99), 3700 Pacific Highway East (Old 99)(Pierce County Control Point 494).
8	FN-8	701797.7310	1175263.3332	16.12	b/m fn8	Top of monument in case, centerline Alexander Avenue, 130 feet south of Pacific Highway East (Old 99). 1/16 corner monument.
9	FN-9	701993.1176	1176595.8749	10.89	x fn9	"X" on concrete curb southeast corner parking lot at 4507 Pacific Highway East (Old 99) at the northwest corner of Pacific Highway East (Old 99) and 46th Avenue East.
10	FN-10	703079.3449	1177287.1580	9.93	x fn10	"X" on south of rim to monument case at Willow Street and 12th Street East.
11	FN-11	702036.2560	1177657.8057	10.87	bolt fn11	Top of southeast bolt to area parking light standard, 82 feet north of sidewalk at 4813 Pacific Highway East (Old 99), in Fife Business Park.
12	FN-12	701825.5510	1178702.0064	11.97	x fn12	"X" on northwest corner concrete pad for Pierce Transit shelter, south side Pacific Highway East (Old 99) 50 feet east of entrance to Fife Plaza, 5204 Pacific Highway East (Old 99).
13	FN-13	704399.6590	1178663.1200	6.21	spike fn13	Railroad spike centerline 8th Street East, west of 54th Avenue East at dead end.

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14	FN-14	705730.1000	1179364.9900	9.54	b/m fn14	Top of Washington DOT brass monument in case. Intersection of 4th Street East and 54th Avenue East.
15	FN-15	701742.7093	1179322.1809	11.10	spike fn15	"X" top northwest corner concrete side walk of business 5402 Pacific Highway East (Old 99), Mitzel's Restaurant, in the southeast quadrant of 54th Avenue East and Pacific Highway East (Old 99).
16	FN-16	702970.4200	1179327.7620	11.65	x fn16	"X" on northwest corner of Tacoma Power concrete electric vault at the southeast quadrant of 54th Avenue East and 12th Street East.
17	FN-17	704403.6100	1179270.2380	8.46	x fn17	"X" on southwest corner of concrete pad for electrical junction box to pump station number 4 at northwest intersection of 54th Avenue East and 8th Street East.
18	FN-18	707106.3595	1179417.7400	7.15	b/m fn18	2 inch brassie, end of 54th Street East section corner.
19	FN-19	701877.6637	1180635.2933	11.60	x fn19	"X" on southeast corner base entrance sign to Royal Coachman Motel at 5808 Pacific Highway East (Old 99).
20	FN-20	702978.3660	1180532.9701	10.21	x fn20	"X" on rim south side of storm water manhole between sidewalk and south street curb 12th Street East east side drainage ditch (1320' +/- east of 54th Avenue East).
21	FN-21	702210.8422	1179424.2703	6.96	x fn21	"X" on northeast corner concrete pad for fire hydrant south side 15th Street East 155 feet east of 54th Avenue East. Northeast drive of Columbia Bank.
22	FN-22	701628.6830	1181693.4750	13.29	b/m fn22	Small dome brassie, centerline 62nd Avenue East, 100 feet south of Pacific Highway East (Old 99). South quarter corner Section 6 (Pierce County Control Point 089).
23	FN-23	702997.1636	1181712.8301	14.15	x fn23	"X" on northwest corner concrete electrical vault in the northwest quadrant of 12th Street East and 62nd Avenue East. Located 0.5 feet north of sidewalk.
115	FN-24	702012.5185	1183811.1697	18.81	b/m fn24	Corps of Engineers brass cap BMTS1 at base of concrete guardrail at the southwest of bridge over Hylebos Creek at Pacific Highway East (Old 99). Established by Western Aerial Surveys, Inc.
51	FS-1	701305.4020	1170692.9550	8.46	spike fs1	Railroad spike east side entrance to 2902 20th Street East, 15 feet west of fire hydrant and 35 feet north of east entrance gate post.

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52	FS-2	700551.7053	1172024.1300	12.12	x fs2	"X" in northeast corner of concrete pad around fire hydrant. Southeast corner of junction 20th Street East and Port of Tacoma Road.
53	FS-3	700502.2400	1173154.8287	11.98	r/b fs3	7/8" rebar driven flush with paving at most northwesterly corner of parking lot at the southeast corner of the intersection of Industry Way South and 20th Street East.
54	FS-4	700462.2841	1174486.9400	13.76	spike fs4	Railroad spike east side of east drive to 3500 20th Street East 10 feet south of sidewalk next to curb.
55	FS-5	700479.7930	1175218.4205	19.14	b/m fs5	Brassie 20th Street East and Goldau Road.
56	FS-6	700469.2300	1176589.8400	12.27	x fs6	"X" in southeast corner of concrete pad of phone box #4605. North side of 20th Street East at junction of 20th Street East and Frank Albert Road, 15 feet west of drive to 4609 20th Street East.
57	FS-7	699133.9200	1176612.2150	17.69	spike fs7	Railroad spike south side of drive to 2105 Frank Albert Road. 3.5 feet east of sidewalk 29 feet east of brass surface monument (1/16 corner).
58	FS-8	698082.6400	1176532.2800	53.58	xfs8	"X" center of sidewalk southeast corner of bridge over railroad on Frank Albert Road.
59	FS-9	696188.7715	1176416.4500	24.59	spike fs9	Railroad spike on the south edge of North Levee Road, 8 feet west of the centerline of Frank Albert Road.
60	FS-10	700375.5200	1177919.0700	13.05	spike fs10	Railroad spike adjacent to sidewalk at end of curb west side of drive 4918 20th Street East.
61	FS-11	700335.6313	1179284.4700	11.84	x fs11	"X" northeast corner of sidewalk east entrance to Fountain Memorial Park on 20th Street East.
62	FS-12	699214.0900	1179166.9500	17.90	spike fs12	Railroad spike center west parking lot Catholic church 87 feet south of power pole H-2 at 2303 54th Avenue East.
63	FS-13	698237.6500	1179145.3849	19.84	spike fs13	Railroad spike at end of concrete curb for driveway on north property line at 2601 54th Avenue East.
64	FS-14	697409.3300	1179114.6400	19.96	x fs14	"X" on east rim sanitary sewer manhole at 2901 54th Avenue East.
65	FS-15	696417.8100	1179063.5200	19.50	b/m fs15	Pierce County standard brassie, section corner 12, 7, 13, 18.
66	FS-16	698610.8233	1179993.2200	18.47	x fs16	"X" on southeast corner concrete sidewalk at 5619 Valley Avenue.

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67	FS-17	697961.1100	1181543.4700	16.83	x fs17	"X" on southeast corner concrete pad of fire hydrant at northeast corner of intersection at 62nd Avenue East and Harry Smith Road.
68	FS-18	697126.2400	1182035.0900	18.94	rod fs18	2 inch iron bar, center intersection of Sheffield Lane East and Wilton Lane East, 70 feet east of entrance gate.
70	FS-20	696316.2341	1181631.3552	22.07	b/mfs20	Brassie center cul-de-sac at end of Holm Drive.
71	FS-21	696301.6900	1182862.4400	26.51	x fs21	"X" northeast corner concrete pad for fire hydrant at truck entrance 6611 Valley Avenue. Across street from 6602 Valley Avenue.
72	FS-22	696284.6100	1184224.5300	26.34	pk fs22	PK northwest corner Tacoma Power concrete vault northeast corner of intersection Valley Avenue and 70th Avenue East.
73	FS-23	700300.9944	1184243.8600	18.35	x fs23	"X" southwest corner concrete pad for electric vault at northwest corner of intersection of 20th Street East and 70th Avenue East.
74	FS-24	700208.6300	1186406.3238	26.07	x fs24	"X" northwest corner concrete pad for electric vault at southwest corner of intersection of 20th Street East and Freeman Road.
75	FS-25	700293.1800	1182972.1300	16.84	b/m fs25	Brassie on 20th Street East, which is the southwest corner of the northeast quarter of the northeast quarter of Section 7 about 66th Avenue East.
77	FS-27	700336.7223	1180403.5600	12.00	b/m fs27	Brassie intersection 20th Street East and 58th Avenue East.
78	FS-28	700270.4000	1181578.9900	12.44	x fs28	"X" southwest corner of concrete pad for electric vault at southwest corner of 20th Street E and 62nd Avenue East.
79	FS-29	698482.2500	1184032.8800	21.42	x fs29	"X" concrete curb 2 feet north of fire hydrant. 200 feet west centerline 70th Avenue East, south entrance to 2400 70th Avenue East.
80	FS-30	697623.8800	1184271.2600	22.31	x fs30	"X" southwest corner of concrete electric vault at the northeast corner of intersection of 70th Avenue East and 28th Street East. South entrance to 2707 70th Avenue East.
81	FS-31	693547.8200	1184098.7959	23.12	b/m fs31	Standard Pierce County brassie, 2 feet west of centerline 70th Avenue East, 1/16 corner.
82	FS-32	690458.4900	1183991.8500	31.23	b/m fs32	Standard Pierce County brassie bench mark in island 35 feet east of centerline of 70th Avenue East and 20 feet north of centerline of North Levee Road (Pierce County Control Point 161-7).

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83	FS-33	696432.9600	1188107.8300	32.68	spike fn33	Railroad spike south side of south entrance to Fife Sand and Gravel, 3120 Freeman Road. 20 feet west centerline Freeman Road.
84	FS-34	693406.6900	1188079.9900	34.57	spike fs34	Railroad spike in island intersection of Valley Avenue and Freeman Road. Southwest quadrant of intersection.
85	FS-35	694462.4700	1186740.4097	31.48	b/m fs35	Top Pierce County bench mark brassie, 40 feet south centerline of Valley Avenue and 25 feet west centerline of 78th Avenue East.
86	FS-36	691696.4192	1188003.0029	29.63	b/m fs36	Top 2" brassie south side asphalt drive to Fife Fire and Rescue, Firwood Station, 20 feet east of front entrance on west side of 4500 Block of Freeman Road (Pierce County Control Point 163-2).
87	FS-37	690901.7800	1186679.3300	28.37	pipe fs37	1" pipe with tack east bound lane of 48th Street East at intersection of 78th Avenue East (Private Road).
88	FS-38	690909.6400	1188007.1100	29.09	b/m fs38	Brass surface monument intersection 48th Street East and Freeman Road.
90	FS-39	692316.5331	1181883.1948	29.10	b/m fs39	Top Pierce County bench mark brassie, 15 feet east centerline drive to residence 6215 North Levee Road East, 12 feet north of centerline North Levee Road East (Pierce County Control Point 161-9).
91	FS-40	694611.9200	1179018.2800	27.43	b/m fs40	Top Pierce County surface brassie, intersection of North Levee Road and 54th Avenue East.
92	FS-41	697710.4705	1173852.1600	21.37	spikes 41	Railroad spike south edge North Levee Road at intersection of North Levee Road and Berens Road.
116	FS-42	698011.2743	1179130.5960	22.86	bolt rail fs42	Top of nut on southern most guardrail support post at upstream side of 54th Avenue East crossing of Wapato Creek.