

# City of Redwood City Height Modernization Project

## Table of Contents

- I. Executive Summary
- II. Project Scope
- III. Methods Used
- IV. Quality Assurance Procedures
- V. Benchmark Elevations, Descriptions, and Coordinates
  - a. Set Benchmarks
  - b. Recovered Redwood Shores Benchmarks
    - i. Elevations and Coordinates, NAVD88
    - ii. Descriptions and Elevations on RWS Datum
  - c. Recovered Redwood City Benchmarks
    - i. Elevations and Coordinates, NAVD88
    - ii. Descriptions and Elevations on RWC Datum
- VI. Level Notes
- VII. Contents of Included CD
  - a. Shapefile
  - b. Photos
  - c. Record of Survey
  - d. Data spreadsheet

## **I. Executive Summary**

The 2007 Redwood City Height Modernization Project established a new set of benchmarks on the North American Vertical Datum of 1988 (NAVD88). NGS point "G110 RESET" was held to establish the vertical project datum.

The following steps were performed:

1. Seventy-seven (77) two inch stamped brass discs were set in Redwood City. Eleven (11) were set in Redwood Shores, eleven (11) in Emerald Hills, and the remainder in other parts of Redwood City, with the greatest concentration in the downtown area.
2. Starting with G110 RESET, first order level loops were run and adjusted to all the new benchmarks except the ones in Emerald Hills.
3. RTK GPS was used to establish horizontal coordinates for each benchmark based on California State Plane Coordinate System, 1983, Zone 3, US Survey Feet.
4. Real Time Kinematic (RTK) GPS elevations were accepted for the eleven benchmarks in Emerald Hills, where no leveling was performed due to steep slopes.
5. Two photographs were taken of each benchmark to aid in recovery.

In addition to setting 77 new benchmarks, the existing benchmarks in Redwood Shores and central Redwood City were leveled to, located with GPS, and incorporated into the report.

The final deliverable includes adjusted elevations for all set and recovered benchmarks (except for Emerald Hills, where RTK GPS is used for elevation), descriptions for all set benchmarks, horizontal coordinates for each point in State Plane and WGS84 coordinate systems, digital photographs, ESRI shapefile, and a spreadsheet of all points set and recovered.

## II. Project Scope

The project establishes accurate, vertical survey control for the City of Redwood City using the North American Vertical Datum of 1988 (NAVD88). Seventy-seven brass disc benchmarks were placed throughout the city. The benchmarks were placed at approximately quarter mile density in central Redwood City (defined as being between Veterans Blvd. and Hudson St. and Whipple Ave. and Charter St.) and approximately half mile density in all other areas of the city.

All 66 of the benchmarks lying to the east of Alameda de las Pulgas and those in Redwood shores were leveled to using a first order level loop. The remaining 11 benchmark elevations in Emerald Hills were measured using RTK GPS.

All benchmarks were located using RTK GPS. The GPS measurements provided an additional quality control check of level data. The horizontal coordinates can be useful to help recover the benchmarks.

Two digital photos were taken of each set and recovered benchmark. One was a close-up of the benchmark or lid, the second was a profile shot showing the vicinity around the benchmark. The photos are on the included CD.

To simplify public access to the data, a Record of Survey was prepared for San Mateo County.

### Scope Summary:

- ◆ Quarter-mile benchmark density in central Redwood City.
- ◆ Half-mile benchmark density in Redwood Shores, Emerald Hills, and remaining Redwood City.
- ◆ First order level of 66 benchmarks outside of Emerald Hills.
- ◆ GPS elevation measurement of 11 benchmarks in Emerald Hills.
- ◆ Create Record of Survey to provide public access to elevation data.
- ◆ Recover benchmarks in Redwood Shores.
- ◆ Recover benchmarks in Redwood City.
- ◆ Two photos of each benchmark.
- ◆ Prepare Record of Survey for San Mateo County

### Stated accuracy:

Vertical datum based on 2<sup>nd</sup> order GPS control network. G110 RESET held.

First order level loops run to all benchmarks from G110 RESET.

Trimble R8 GPS: Horizontal Accuracy 1cm +/- 1 ppm (x baseline length)

Trimble R8 GPS: Vertical Accuracy 2 cm +/- 1 ppm (x baseline length)

Trimble DiNi 12T: Vertical Accuracy, Standard Deviation for 1 km 2-way leveling,  
1mm

### **III. Methods Used**

The nearest First Order NAVD88 control is 11 miles west of Redwood City in Half Moon Bay. Another one is located across the bay in Alameda County. It would be impractical to level such great distances to utilize those points to establish the new benchmarks in Redwood City with any degree of accuracy. We accepted the National Geodetic Survey Point G110 Reset which appears stable and is located in San Carlos about 0.8 miles North of Redwood City. G110 Reset is a horizontal control point and is part of the South San Francisco Bay Height Modernization project. NAVD88 elevation of G110 Reset is therefore GPS derived and not first order. If NGS upgrades or readjusts the value it may result in a minor systematic correction to Redwood City benchmarks.

To select locations for the benchmarks, we marked potential locations on a map of Redwood City. Benchmarks were at a half-mile density everywhere except in Central Redwood City, where quarter-mile density was used. We then visited each potential location and assessed its suitability based on accessibility for use by other surveyors, tree cover (for GPS use), and safety. Once a final location was selected, the brass disc was set using a drill and epoxy or grout. The location of the benchmark was measured using RTK GPS. Next, two digital photos were taken.

We ran First Order differential level loops using a Trimble DiNi12T digital level from G110 reset into Redwood City and then spread that control North, South East and West in smaller closed (adjusted) loops. The same procedure was performed for Redwood Shores. Closure calculations are included in section VI of this report.

A similar procedure was used for the recovered benchmarks. The only difference was that the benchmarks didn't need to be set.

This report includes the descriptions of each benchmark, horizontal coordinates in State Plane and WGS84, and elevations, photos, a spreadsheet of data collected, and the Record of Survey to be recorded with San Mateo County.

Equipment Used:

Trimble Dini 12T Digital Level

Invar Rod

Trimble R8 GPS

Benchmarks Set:



#### **IV. Quality Assurance and Control**

The Trimble DiNi 12T can be set to maintain 1<sup>st</sup> Order Level Loop standards of accuracy. It informs the user of any blunders, mistakes, or significant losses in accuracy while the level loop is being performed. Once the loop is closed, any misclosure is stated and is later adjusted to evenly distribute any error. Details of this error are shown section VI "Level Notes".

Spreadsheet software was used to add a second check to data collection. Due to the size of the project and the nature of the TDS data collection software, it was necessary to import all level data into a spreadsheet where it could be analyzed in a way similar to that of a balance sheet. Adjustments made to one loop correctly adjust data within all subsequent associated level loops. We were able to ensure spreadsheet integrity and identify any inconsistencies by observing this.

As a third check, GPS Vertical data was compared to level data. Once the data was adjusted in the spreadsheet, each elevation was compared to the measured GPS elevation. This provided a blunder check.