McCurry Hydrology, LLC

Memorandum

To: Mr. David Rechberger, Twin Lakes Action Group
From: Gordon McCurry, Ph.D.
Date: June 24, 2015
Subject: Preliminary Hydrologic Analysis of the BCHA Property at 6655 Twin Lakes Road

The Boulder County Housing Authority (BCHA) purchased a 10-acre parcel located at 6655 Twin Lakes Road in May 2013 with the goal of developing this undeveloped land to provide affordable housing. Residents of the surrounding community are concerned that developing this land could lead to an increase in basement flooding problems in this high-groundwater area. This memorandum presents my preliminary analysis of the hydrology of the subject property and surrounding areas, and provides recommendations on how to reduce flooding-related impacts related to developing the BCHA property.

Site Environmental Setting

The BCHA property is located northeast of the City of Boulder in unincorporated Boulder County in the south-central portion of Section 11of Township 1 North, Range 70 West. The land is undeveloped with a native grass cover (Figure 1). The property ranges in elevation from approximately 5175 to 5160 feet and slopes gently to the southeast towards Boulder Creek. The northern edge of the BCHA property corresponds approximately to the surface water drainage divide separating the Dry Creek drainage to the north and a portion of the Boulder Creek drainage to the south, within which the property lies. South of the property are several small intermittent eastward-flowing streams that drain into Boulder Creek. Soils in the area consist of clay loam and clay, defined by the USDA Natural Resources Conservation Service as Nunn B and Longmont B soils (NRCS, 2015). The BCHA property contains about equal areas of both soil types (Figure 2). Underlying the soils is the Pierre Shale, a regionally extensive and low-permeability bedrock layer (USDA, 1975). Borehole logs from wells drilled in the vicinity of the BCHA property and the Twin Lakes neighborhood indicate that the depth to bedrock is approximately 10 to 15 feet below ground surface. A shallow aquifer exists within the soils that overlie the shale bedrock.

Hydrology Near the BCHA Property

Several man-made features exist in the area that dominates the hydrology of the BCHA and surrounding properties. North of the property are two lakes and three regional irrigation ditches. The West and East lakes are part of a 42-acre County Open Space Twin Lakes property. The lakes have been in use since 1910 to store water used for agricultural purposes (BCPOS, 2004). Portions of both lakes are adjacent to the northern edge of the BCHA property. The West and East lakes cover areas of approximately 16 and 11 acres, respectively, and have a combined storage capacity of 218 acre-feet (approximately 71 million gallons). The embankments for the

lakes consist of compacted earth fill (GEI Consultants, 2014). Wetlands exist around the lakes as a result of seepage through the lake bed and berms, creating shallow groundwater conditions (BCPOS, 2004).

In 2014 the Boulder and Left Hand Ditch Company sponsored a study of potential impacts of dam breaches of two of its reservoirs (GEI Consultants, 2014). One of these reservoirs is referred to in this report as the East Lake of the Twin Lakes open space. The impoundment for the East Lake has a State dam safety rating indicating there could be significant property damage if there is a dam failure (BCPOS, 2004). A hypothetical breach of the East Lake's dam was modeled and inundation maps were generated. The dam for this lake, Davis No. 1 Dam, is constructed as a dike that rings the eastern portion of the lake. Failure scenarios were modeled for both a northern and a southern dam breach. The southern breach scenario was felt to be smaller in magnitude than the northern breach. A portion of the hypothetical southern breach would discharge to the southeast, across the eastern portion of the BCHA property and through the neighborhoods southeast of the East Lake as water flows to Boulder Creek (GEI Consultants, 2014). The modeled southern breach had a peak flow of 600 cfs, roughly equivalent to high spring-time flows of Boulder Creek through town. Maximum flow depths to the southeast were modeled to be approximately one foot (Figure 3).

Located between the two lakes and the BCHA property are the North Boulder Farmer's Ditch, the Boulder and Left Hand Ditch, and the Boulder and White Rock Ditch. The former two ditches merge beginning west of 63rd Street and then the resulting two ditches run parallel to each other, traversing south of the West and East lakes and continuing to the east (Boulder County, 2000). The Boulder and Left Hand Ditch Irrigation Company retains the right to use the West and East lakes for storage purposes (BCPOS, 2004). Over the past 20 years an average of approximately 145 acre-feet per year has flowed through the ditches to supply the lakes. Like most ditches, these are unlined and likely leak a portion of their water to the underlying soils and shallow groundwater system, supporting the wetlands vegetation and lush growth around them.

Another hydrologic feature of note for the Twin Lakes community is the Boulder Supply Canal. This is a large-capacity canal located west of the Boulder Country Club neighborhood, adjacent to Carter Court and Carter Trail that define the west side of that neighborhood. The Boulder Supply Canal allows excess water in Boulder Reservoir to discharge to Boulder Creek (DWR, 2005). Although concrete-lined, it was built in 1955 and so it is likely that some leakage occurs through joints, cracks and areas of degraded concrete whenever it is in use.

Within and south of the residential areas south of Twin Lakes Road is a small lake and an intermittent stream that includes several areas containing wetlands-type vegetation. These water features also provide water to the underlying shallow aquifer system. The wetlands are an indication of shallow groundwater conditions in this portion of the residential area south of the BCHA property.

Hydraulic Limitations in the Vicinity of the BCHA Property

Twin Lakes, two irrigation ditches, and to a lesser extent a supply canal are all located hydraulically upgradient of and in close proximity of the BCHA property and surrounding residential areas. Collectively these provide ample sources of water to feed the area's shallow groundwater system. The water table of the shallow groundwater system is located relatively close to the land surface as shown by the commonly-occurring wetlands present in the area. The shallow depth to bedrock helps support and maintain the shallow aquifer. In addition, many homes in the Twin Lakes neighborhoods have sump pumps which are further evidence of shallow groundwater.

The USDA Natural Resources Conservation Service has compiled soils data and developed an interactive web-based graphical database that allows the user to examine the suitability of a given area to a set of potential uses (NRCS, 2015). The suitability analyses are based on geotechnical and engineering properties of the soils. The soils beneath the BCHA property (Figure 2) were evaluated as part of this preliminary hydrologic analysis as to their suitability for the construction of dwellings. Dwellings are defined by the NRCS as single-family houses of three stories or less. For dwellings with basements, the foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of approximately 7 feet. For dwellings without basements, the foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of 2 feet or at the depth of maximum frost penetration, whichever is deeper.

Each soil type is assigned a suitability rating based on the limitations posed by individual soil properties. Two sets of criterion are applicable to dwellings: (1) properties that affect the ability of the soil to support a load without movement and (2) properties that affect excavation and construction costs. The properties that affect the load-supporting capacity include depth to a water table, ponding, flooding, subsidence, linear extensibility (shrink-swell potential), and compressibility (inferred from the Unified Soil Classification System classification of the soil). The properties that affect the ease and amount of excavation include depth to a water table, ponding, flooding, slope, depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, and the amount and size of rock fragments.

Ratings indicate the extent to which the soils are limited by each of the applicable soil properties that affect the specified use, in this case the construction of dwellings. Numeric ratings are provided and indicate the severity or degree with which a given soil property contributes to the overall suitability rating. An assigned rating of "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. An assigned rating of "Somewhat limited"

indicates that the soil has features that are moderately unfavorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. An assigned rating of "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected (NRCS, 2015).

The suitability of soils for accommodating dwellings on and near the BCHA property was found to be somewhat limited to very limited for dwellings with basements (Figure 4). The main reasons were due to flooding potential and shallow depth to groundwater, and the shrink-swell potential of the soils. The flooding potential and shallow depth to groundwater are expected outcomes given the number and proximity of water sources in the immediate vicinity. The shrink-swell potential is associated with the shrinking of soil when dry and the swelling when wet – a common feature of many clay-rich soils. Shrinking and swelling of soil can damage roads, dams, building foundations, and other structures (NRCS, 2015). The suitability to accommodate dwellings without basements on and near the BCHA property was found to be very limited, for the same reasons.

To minimize the impacts from flooding potential, shallow groundwater and shrink-swell of the site soils, dwellings built on the BCHA property may require additional design components. These may include addition foundation footers, exterior tile drains around the foundations, sump pumps in basements and crawl spaces, setbacks for landscaping, and gutter downspouts that extend beyond a critical setback distance from the dwellings.

Hydrologic Concerns Associated with Development of the BCHA Property

The preceding discussion suggests potential limitations associated with constructing dwellings on the BCHA property and offers general guidelines to mitigate those limitations. However, it does not address potential hydrologic impacts to adjacent residential buildings associated with development of the property. The key impacts are:

- higher risk of basement flooding,
- increases in the frequency and/or volume required to be pumped from homes with existing sump pump systems, and
- the need for homes to install and operate sump pump systems that historically have not had to do so.

The causes of these potential impacts relate to constructing dwellings, dwelling foundations and foundation footers, and even the sump or drain systems that might be installed for the new homes. Dwellings typically are constructed so that the soil beneath the building foundation supports some of the weight of the building, with the remaining load supported by foundation

footers. The weight of a structure compresses the underlying soil. Sand- and gravel-rich soils have very little compressibility but the clay-rich soils beneath the BCHA property are likely to have a relatively high compression potential. In the northern portion of the BCHA property where shallow depth to groundwater is more likely due to the nearby lakes and irrigation ditches, it is possible that compressed soils could extend below the water table. If this were to occur, the groundwater previously occupying those pore spaces in the soil would be displaced and would migrate elsewhere. Depending on the density of building construction and how close those buildings were to existing residences, at least some of the displaced groundwater would migrate toward the existing residences with a resulting rise in the water table and increased risk of basement flooding. Deep foundation footers or foundations that extended to the underlying bedrock would similarly displace existing groundwater.

In addition, sump or drain systems that might be installed in new dwellings could also pose an addition hydrologic risk to nearby homes. It is common for water extracted from sump/drain systems to be discharged into nearby gutters or storm drains. Depending on how the storm drain system for the new dwellings is designed, the extracted water may end up infiltrating along the edges of the BCHA property which would lead to higher groundwater conditions for the adjacent residences.

An additional hydrologic concern associated with development of the BCHA property, which one hopes never occurs, is the impact of a dam breach of the East or West lakes on the Twin Lakes property. The hydraulic analyses conducted for the East Lake indicates a portion of the discharge from a hypothetical southern breach would traverse the east side of the BCHA property. Should homes be constructed in that area, their presence would divert the flows caused by the breach and, based on the inundation analyses, most of that diverted water would be routed to the neighborhood to the east. No analysis was performed for a breach of the West Lake, but it is reasonable to assume that newly built dwellings on the BCHA property would also divert some of the released lake water into adjacent neighborhoods.

Conclusions

Before any dwellings are built on the BCHA property the developer must take into account the shallow groundwater conditions that likely exist in the region so that existing homes are not adversely affected. Any homes that are built should be designed to overcome the limitations posed by flooding potential, shallow depth to water, and shrink-swell conditions of the soil. Installing wells on the property and instrumenting them to characterize the depth to groundwater in the shallow aquifer, over the course of at least one year, and performing geotechnical testing on soils are both necessary to better characterize the hydraulic properties and gain a better understanding of potential impacts to adjacent residences.

References

BCPOS, 2004. Twin Lakes Open Space Draft Resource Evaluation & management Plan. Boulder County Parks and Open Space.

Boulder County, 2005. Boulder County Ditch and Reservoir Map. Prepared by Boulder County, Colorado. September.

DWR, 2005. Task 5 – Key Structure Operating Memorandum for City of Boulder. Submitted to the Colorado Division of Water Resources, as part of the South Platte Decision Support System.

GEI Consultants, 2014. Hayden Reservoir Dam and Davis Dam No. 1 Dam Breach Inundation Mapping Report. GEI Consultants Inc, submitted to Boulder and Left Hand Ditch Company.

NRCS, 2015. Web-based soil survey database. Accessed June 2015 http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

USDA, 1975. Soil Survey of Boulder County Area, Colorado. United States Department of Agriculture, Soil Conservation Service.

Figure 1. View looking northwest at the BCHA property from Twin Lakes Road.

Figure 2. Soils in the vicinity of the BCHA property.

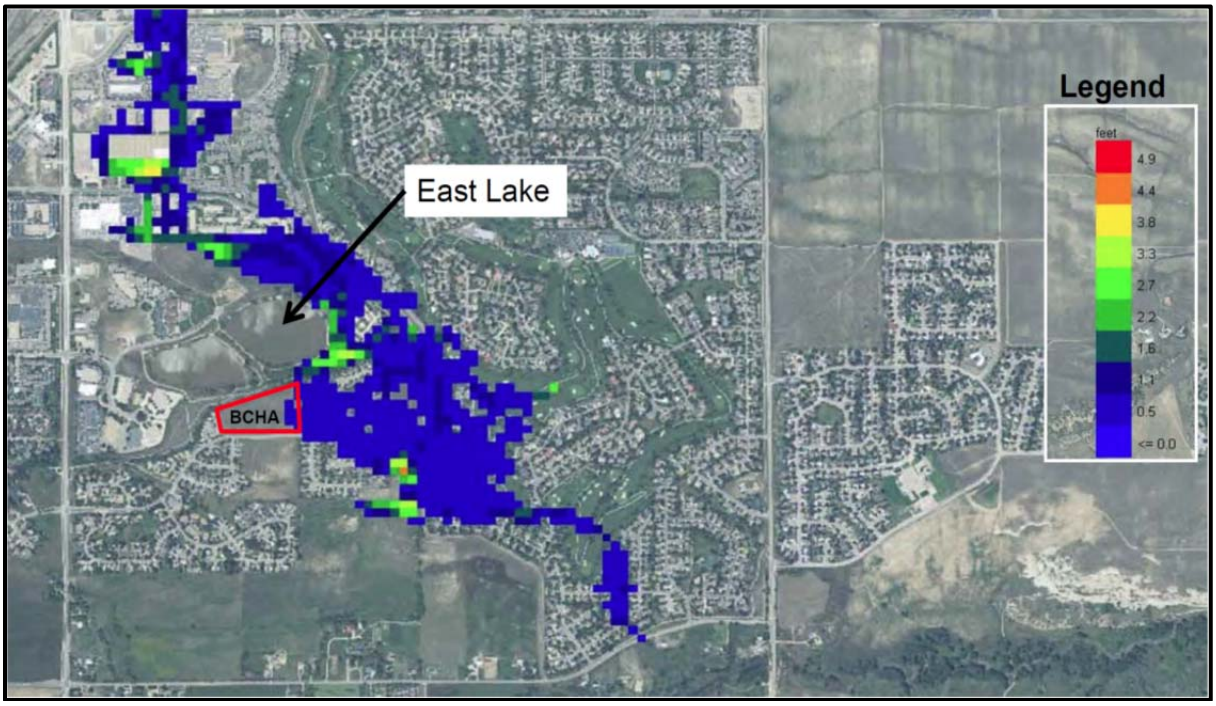

Figure 3. Inundation area and maximum flow depths for a dam breach of the East Lake.

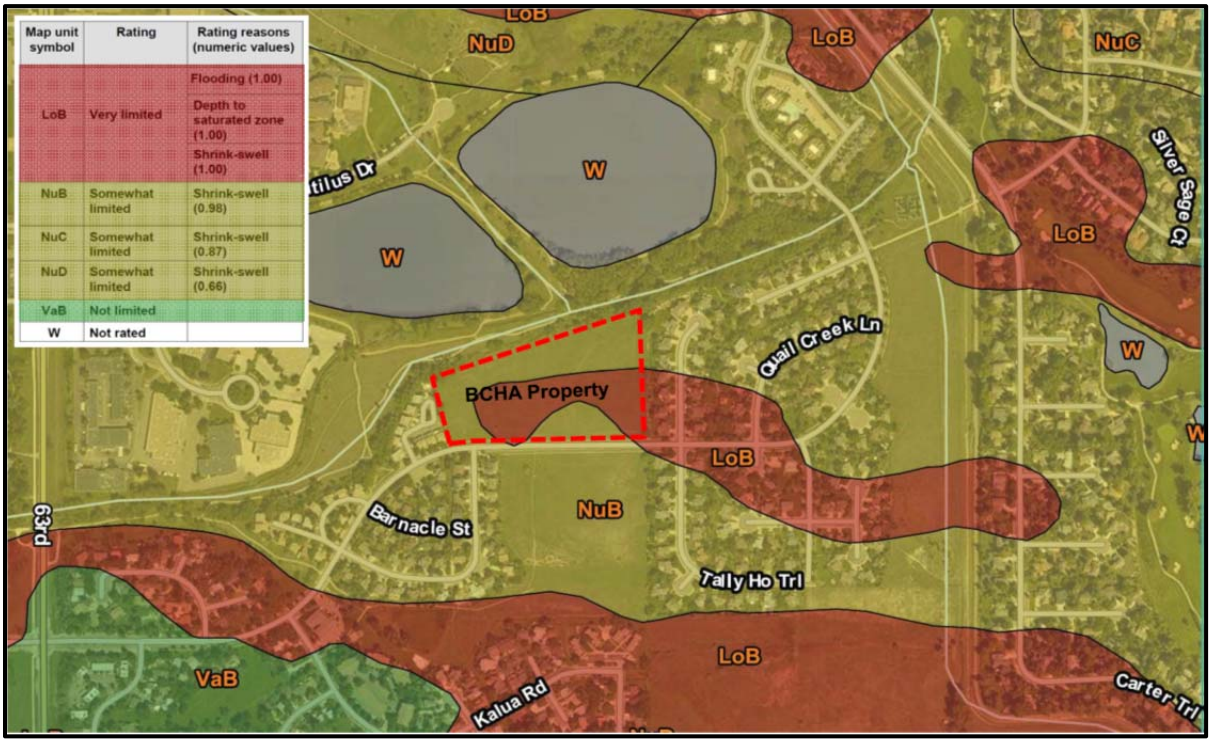

Figure 4. Limitations for construction of dwellings with basements.