DRAFT TECHNICAL MEMORANDUM NO. 1

Town of Windsor - Groundwater Well Siting

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DATE: August 3, 2007

JOB #: 02520-07002-32300

INTRODUCTION

The Town of Windsor (Town) is pursuing the option of additional off-Russian River groundwater wells to augment the existing aqueduct water. Winzler & Kelly Consulting Engineers' (Winzler & Kelly's) objective of this study was to use the known hydrogeology and existing well logs to screen the greater Town of Windsor area for potential well locations. Of particular interest were areas currently owned by the Town and within Town boundaries. The areas surrounding the Town were also included in the evaluation. Nine hundred and sixty-five (965) water well driller logs were obtained from the California Department of Water Resources (DWR) and summarized into GIS format to aid in screening locations (Figure 1). These well logs along with a review of available geological studies were used to identify seven (7), ½-mile radius areas for possible drilling of a municipal well (Figure 2).

DATA COLLECTION AND GIS MAPS

The first task of the study was to complete a records search of all historic well logs and summarize the information into a GIS based map of all the well locations in the Town and surrounding area. Winzler & Kelly did not verify which wells are currently in use, but all logs are recorded in the database. The boundaries of the study area extended past the Town limits; to the Russian River to the west; to Mark West Creek to the south; to the Foothill and Shiloh Regional Park areas to the East; and to just south of Milk Barn Road to the north. Although the Town is not focused on drilling municipal wells along the Russian River Plain, the data is presented in this Technical Memorandum for comparison and for completeness of the Town well data set.

Water well driller logs were obtained from the DWR (2006/2007). A database was created which included key information from each of the well logs such as owner information, well type, well depth, pumping tests, location, log, and drill dates. A 2006 aerial background of the Town was added and the geology of the area using a USGS Geologic Map was overlain onto the map. Driller logs are not provided in this Technical Memorandum due to the information being considered confidential by DWR.

Next, each record was assigned a geographic identifier (geocoded) and uploaded into a GIS system. Of the 965 well driller logs collected from DWR, approximately 25% could not be accurately located. How each of these was used is described in detail below, and is noted in a column in the database.

- First by Address; a dot for the well was placed in the middle of the parcel.
- Next by street, using the closest address that contains range of street numbers.
- The wells were then either approximately located by the Federal Land Survey System (Township, Range, and Section) or by the description on the log using the latitude and longitude.
- Some logs did not indicate well yield, and were located on the map, but were not included in the yield analysis.
- Well types were identified as they are on the well log and then color coded into one of the following combined type of wells:
  - Municipal
  - Community
  - Domestic
  - Irrigation
  - Industrial
  - Unknown/Other

The result of all the data collection is a database and a GIS map of the Town and surrounding areas. Attached are two figures that depict the basic information provided in the system used for the analysis: Figure 1 shows the aerial photo background of the Town, Town Limit lines, waterline infrastructure, major roads, and all identified wells color coded according to their type of well; and Figure 2 depicts the same scale of the Town, but with the geology and all the wells changed to one color, but the size of each well changed according to the yield analysis.

HYDROGEOLOGIC ANALYSIS

The data obtained from geologic publications, the DWR logs, and maps created using this data were reviewed to identify areas with groundwater development potential. The analysis was based on the geology, hydrogeology, historic groundwater yields, and depths from the 965 wells in the area. Below is a summary of the hydrogeology and geology in the Windsor area.

BASIN HYDROGEOLOGY

The Town of Windsor is located in the northern portion of the Santa Rosa Valley Groundwater Basin, which occupies a northwest-trending structural depression in the southern part of the Coastal Ranges north of the San Francisco Bay of northern California. The Santa Rosa Valley has been divided into three groundwater subbasins, including the Santa Rosa Plain Subbasin, Healdsburg Subbasin, and Rincon Valley Subbasin (DWR, 2004). Windsor is located in the northern portion of the Santa Rosa Plain Subbasin. The Santa Rosa Plain Subbasin is bounded on the west by the Russian River, on the north by the Healdsburg subbasin and the Mendocino Range; on the south by a drainage divide that separates the Santa Rosa Valley from the Petaluma Valley Groundwater Basin; and to the east, by the Mayacama Mountains.

The primary sources of groundwater recharge in the Town area are precipitation in the valley, stream seepage from the Russian River and Mark West Creeks, as well as the minor streams and creeks traversing the Town such as Windsor Creek and Pool Creek. The streams and the Russian River can alternate and can alternate as points of discharge as well as areas of recharge during the drier seasons. In these areas, groundwater discharges as underflow to the streams or adjacent low-lying areas.

Groundwater production along the Russian River is excellent; however, quantity availability problems stem from reliance on groundwater in these areas due to the lack of alluvial aquifer storage capacity during the drier seasons. The Russian River wells rely on the flow of the river, which is at least partially supplied by the controlled discharge from the Warm Springs Dam, operated by the Sonoma County Water Agency. The allowable flow rate in the Russian River is controlled by endangered species fishery issues, which require low in-stream flow requirements during the drier season.

TOWN GEOLOGY

Groundwater within the Town area mainly occurs in the river alluvium, mostly along the Russian River and in the Glen Ellen Formation. In addition, there is relatively young (Quaternary) alluvium associated with Russian River tributaries (i.e., Mark West Creek) overlying the Glen Ellen Formation (Figure 2). The Wilson Grove Formation is one of the major water producers in Sonoma County, but limited in extent to only surfaces south of the Town. There are also two variable low yielding formations: one is the Franciscan Complex, which forms the basement rock under the entire area; and the other is the Sonoma Volcanics, which forms the hills to the east (Mayacama Mountains).

Where available from the literature, we provide an estimate of specific yield. Specific yield is the ratio of the volume of water that a given unit will yield by gravity to the volume of the unit and is usually stated in a percentage. In general, formations with higher specific yield are better for production wells.

Franciscan Complex (Jurassic-Cretaceous): Basement rocks consist of the Franciscan Complex, which is the oldest geologic unit within the Windsor area. This unit is not a viable source of water for a municipal production well. This unit consists chiefly of sandstone, shale, chert, greenstone, and serpentinite. Sandstone is the predominant rock type of the formation, but large areas consist of rock mélange and a mixture of broken rock masses in a sheared matrix of shale. In the southwestern portion of the study area, the Franciscan bedrock is exposed at the surface or capped by a relatively thin section of the Wilson Grove Formation.

Sonoma Volcanics (late Miocene to Pliocene): The Sonoma Volcanics are a thick sequence of volcanic material consisting of lava flows, tuffs and intrusive rocks (Ford et. al. 1975). In the Windsor area, the Volcanics interfinger with the Wilson Grove Formation. The Sonoma Volcanics border the eastern edge of Windsor and into the foothills, but also may extend under the plain a short distance.

Productivity of water wells within this unit is highly variable, ranging from dry wells to wells with yields that are adequate for domestic purposes. Some of the better producing wells may yield 10 to 50 gallons per minute (gpm), (Ford et. al. 1975). Specific yields range from 0 to 15% (DWR, 1982). Water yields from rocks in this formation are highly variable and extremely unpredictable. The Sonoma Volcanics are not considered appropriate for municipal production wells.

Wilson Grove Formation (formerly known as the Merced, late Miocene to Pliocene or Tertiary): The Wilson Grove Formation is one of the principal water-producing formations in Sonoma County overlying the Franciscan Complex (Fox, 1983). The formation consists of massive beds of fine- to very fine-grained marine sandstone with abundant, localized fossils, and interbeds of clay and gravel. The Wilson Grove Formation is a high producer in areas south of Windsor. However, in the study area the Wilson Grove Formation outcrops only in the southwest corner. The Wilson Grove Formation may underlay the Glen Ellen Formation, but wells drilled in this area did not encounter sediments with characteristics of the Wilson Grove Formation, and it may exist at depths greater than any wells have been drilled to date.

Glen Ellen Formation (Pliocene to Pleistocene): The Glen Ellen Formation consists of consolidated alluvial fan, continental, and flood plain deposits that are highly variable in their water yielding capability. This is the principal unit that most wells are drilled into in the Windsor area. The water yielding properties of this formation are highly variable due to the heterogeneity of the formation. Deposits typically consist of poorly sorted gravel, sand, silt, and clay. Specific yields range from 3 to 7% (DWR, 1983). Domestic well yields generally vary from 1 to 150 gpm (Hauge and Mitchell 1983).

Undifferentiated Alluvial Deposits (Quaternary): The undifferentiated alluvial deposits are composed of a heterogeneous mixture of unconsolidated gravel, sand, silt, and silty clay that extend from the base of foothill areas to parts of the valley floor. The deposits are coarser in foothill areas and are finer-grained in the valley. Due to their overall coarseness, these deposits are estimated to have moderate to high specific yields of 8 to 17% (DWR, 1982a, 1982b). Specific yield is the ratio of the volume of water that a given unit will yield by gravity to the volume of the unit and is usually stated in percentage. Water yields in this formation are highly variable.

Recent Alluvium (Quaternary): A variety of unconsolidated alluvial deposits occur as discontinuous interbeds of gravel, sand, silt, and clay. These undifferentiated alluvial deposits represent a mixture of coarse-grained stream channel and natural levee deposits, and fine-grained flood plain deposits. In the uplands, alluvium occurs as superficial deposits along narrow bedrock stream valleys. Where streams emerge from upland areas, alluvium is restricted to elongated stream valleys that have been incised into underlying alluvial fan deposits. The specific yield is variable, depending on the amount of clay and the thickness of the deposits. Most deposits are <100 feet thick with variable specific yields, ranging from 3 to 15% (DWR, 1982a, 1982b).

DATA ANALYSIS

A statistical summary of the boring log data is presented in the table below. The table below sorts the 965 well driller logs by total depth, well yield, and normalized flow (yield in gpm / well depth in feet). The columns of data are presented to compare the very shallow wells (<100 feet) to intermediate wells (<200 feet) to the deep wells of <400 feet and between 400 feet and the deepest well of 804 feet. General comparisons were drawn from the data and specific numbers are given in the table below:

- 78% of the wells below the Town are <200 feet deep and 37% are <100 feet deep;
- 13 of the wells indicated yield >1,000 gpm, and all of these are located along the Russian River;
- 6% of the wells did not provide yield data on the logs;
- 9% of the wells indicated a normalized flow >1.0 gpm/foot (ft); and
- 2% (21 wells) of the wells indicated a normalized flow >5.0 gpm/ft, with 20 of the 21 wells located along the Russian River Plain with the 21st well located on Gumview and it is <100 feet deep.

Well Depth (Feet)	100 feet deep or less	101-200 feet deep	201-400 feet deep	401-804 feet deep
# of Wells [1]	359	419	182	34
Number of Wells with Significant Yield (gpm)	17 wells over 150 gpm	9 wells over 150 gpm	20 wells over 150 gpm	14 wells over 150 gpm
Normalized Flow [2] **Yield/Well Depth (gpm/ft)**	59 over 1.0 17 over 5.0	12 over 1.0 4 over 5.0	13 over 1.0 0 over 5.0	7 over 1.0 0 over 5.0

Notes: [1] No flow information on 61 well logs
[2] Normalized Flow is explained in the Yield Analysis section below

YIELD ANALYSIS

A review of the DWR well driller logs indicate that most well yields are only very high along the Russian River, in the 1,000 gpm, while most of the wells (891 of 965) were equal to or below the 100 gpm.

To minimize the effect of variable well depth on the observed well yield, the reported well yield was divided by the depth of the well after applying a correction for the depth-to-groundwater. The correction applied was 40 feet for wells >100 feet deep, and 15 feet for wells <50 feet. This was subtracted from the total depth of the well. This provided a "normalized" value for estimating aquifer yield that was used for general comparisons. The results indicate that most of the wells provide <1.0 gpm/ft of well depth. Figure 2 shows the comparison of normalized flow values by location for all wells. For comparison, the Town's Bluebird well had a well yield to well depth ratio of 1.3 gpm/ft, and the Russian River wells were calculated near 50 gpm/ft.

CONCLUSIONS AND RECOMMENDATIONS

As a starting point for selecting well locations, 500 gpm was chosen as a minimum well yield for a new municipal well. Of the 806 well driller logs reviewed by Winzler & Kelly in the Town and surrounding areas, 12 wells were deeper than 500 feet, 18 wells indicated initial production of >500 gpm, with 14 of these in the Russian River Plain. The remaining 4 wells are high producers by virtue of their greater depth in the Glen Ellen Formation.

Geologic reference documents indicate that the flow should be significantly better in the Wilson Grove Formation than the Glen Ellen Formation. However, there are no wells to indicate that the Wilson Grove is located below the Town, but it may exist deeper than the current data indicates.

In general terms, the Town can expect yields on the order of 0.5 to 1.0 gpm/ft for wells deeper than 100 feet (i.e., a 400-foot well would yield about 200-400 gpm) in most locations throughout the study area (similar to the Bluebird well). Lower flow rates and restricted recharge can be expected along the flanks of the eastern foothills, where the Sonoma Volcanics will likely be encountered at relatively shallower depths (this limits well depth and hence, available yield). There are some areas where the Glen Ellen Formation appeared to yield marginally higher flow rates (1.25-2.0 gpm/ft). These areas appear to be associated with alluvial deposits which overly the Glen Ellen Formation.

For this analysis, Winzler & Kelly identified seven (7) areas that appear to have favorable aquifer yield (1.25-2.0 gpm/ft). These are identified as areas within a ½ -mile radius. Based on the expected well yield, the top three areas that have the most probability of high well yields are identified in the table below (1, 2, and 3).

The Hiram Lewis Park area is included as an area of interest because it has similar geologic characteristics as other higher yield areas. However, there is very little existing well data in this area.

Table 1. Within Town of Windsor Limits Possible Drill Sites

Eastside of Highway 101 Areas	West of Highway 101 Areas
Esposti Park Area	2. Golf Course Area
Hiram Lewis Park	Keiser Community Park Area

Table 2. Outside Town of Windsor Limits Possible Drill Sites

Eastside of Highway 101 Areas	West of Highway 101 Areas
Airport Area	1. Pool Creek Area
	3. Northwest Old Redwood Highway Area

Note: See Figure 1 for area locations

Appendix A
Maps

Appendix B
References

References

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