Donner Summit Public Utility District

Groundwater Monitoring Study

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Prepared for
Donner Summit Public Utility District

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1. INTRODUCTION AND PURPOSE

Since 1987, the Donner Summit Public Utility District (the District) has disposed of treated and disinfected wastewater (termed “effluent”) during summer months by irrigating dry ski runs at the Soda Springs Ski Area. The irrigated ski runs are located about five hundred feet south of the South Yuba River, which has high flow rates from snowmelt in spring, and very low flow rates during the summer and fall. During high flow months, the treated effluent is discharged directly to the river. Application to the slopes in summer and fall retains the effluent on land, and supports the growth of dense grasses, wildflowers, lesser willows, and small shrubs. The application results in considerable evapotranspiration, and likely some biodegradation of organics, and thereby reduces potential impacts to river water quality during the low flow periods.

Effluent is applied to the ski runs at or about agronomic irrigation rates using a sprinkler system, such that the bulk of the effluent is evapotranspirated by the vegetation. The vegetation has never been harvested or grazed. The irrigation area has a runoff catch and return system designed to prevent any incidental effluent runoff that may occur from directly entering the river. The site’s soils are relatively thin and overlie bedrock. Historically, groundwater is not monitored at the site because of the shallow bedrock and the limited amount of irrigation that occurs each year compared to the large amount of precipitation that occurs each year from snow. Therefore, the extent and nature of any impacts on groundwater, such as it may exist under or near the effluent irrigation area, are unknown.

In 2009, the District was issued Order No. R5-2009-0034, NPDES No. CA0081621. The Order requires the District to “conduct a study to evaluate the most effective means of monitoring groundwater in the land application area. The study must address the feasibility of installing monitoring wells in regards to the slope of the terrain on the land application area, the soils and subsurface geology in the area, and any other criteria applicable to the monitoring of groundwater in the land disposal area.” The purpose of the monitoring program is to ensure that the effluent application does “not cause the groundwater to exceed water quality objectives, unreasonably affect beneficial uses, or cause a condition of pollution or nuisance”.

To identify and assess potential monitoring well or other monitoring locations, ECO:LOGIC visited the District’s effluent application site on August 6, 2009, and completed background literature research that is described in this report. In addition to observing the effluent application operations, the area between the ski slopes and the South Yuba River was inspected for evidence of groundwater seepage or geologic features that could control the movement or direction of groundwater flow.

2. SYSTEM OPERATIONS

The Soda Springs ski slopes are present on the north side of an unnamed hill that is located south of the South Yuba River, west of Lake Van Norden, and north of Ice (Serene) Lakes (see Figures 1 and 2). The hill has a west-northwesterly trend, and ranges in elevation from 7,352 ft at the summit to about 6,760 ft at the base of the slopes. The top portion of the hill has outcropping volcanic rocks and relatively steep slopes. A break in slope to flatter terrain occurs at the base of these rock outcroppings at an elevation of about 6,960 feet. It is on these lower, flatter slopes of the hill where effluent is applied, over an area of about 45 acres (see Figures 2 and 3).

Average annual site precipitation is about 51 inches per year, most of which falls as snow. Average annual snowfall at the nearby Central Sierra Snow Laboratory is nearly 34 feet (10.4 meters). Snow frequently remains on the ski slopes until late May, and effluent application does not begin until June or early July. Despite heavy spring runoff, most area streams are ephemeral and have little flow by mid-summer as a result of the shallow soils and impermeable bedrock within the watershed which have relatively little groundwater storage capacity.

As shown in Figure 3, the irrigation area is comprised of three fields (labeled Areas I, II and III from east to west), which have largely been cleared of trees. As shown in Figure 2, each irrigation field has a central pressurized pipe running from the base of the slope up to the base of the rock outcropping area. Multiple irrigation pipes that parallel the slope contours branch off from each central pressurized pipe. Sprinklers (shown as small open circles on the pipelines in Figure 2) are connected to these irrigation pipes at regular intervals.. , Each of the three irrigation areas has been subdivided into four zones, labeled A, B, C and D, from the bottom of the slope to the top. Zones B, C and D are operated on a timer system which rotates through the zones on a daily basis to evenly distribute the application of effluent over the area so as to maximize plant growth and minimize any effluent runoff. Zone A sprinklers are not operated due to lower permeability soils in these zones. It is believed that vegetation growing in Zone A is tapping into soil moisture created by effluent irrigation of upslope Zones B, C, and D. If correct, Zone A serves to limit subsurface migration of effluent away from the application area.

Any surface runoff of effluent from irrigation Zones B, C, and D is collected in shallow ditches cut into the hill downslope of Zone B (see Figures 2, and 4 through 12). The ditches direct the runoff to a larger collection ditch located at the base of the hill that in turn conveys the collected water to a lined, irrigation runoff recovery pond located in the northwest corner of the application area (see Figures 13 and 14). Periodically, any water that collects in the pond is returned via pipeline to the treatment facility for reprocessing, and then reapplied to the ski slopes.

During ECO:LOGIC's site visit, a small amount of irrigation runoff was observed from Areas I and II, but none was observed from Area III. The runoff collected in the ditches located near the base of Zone B, but much of the collected water appeared to re-infiltrate the land surface (thereby providing subsurface irrigation of the grasses in Zone A) before reaching the main collection ditch. Only stagnant water was observed in the collection ditch near the lined recovery pond.

A small amount of natural spring seepage occurs near the bottom of Area II, Zone B. Donner Summit PUD personnel indicated that the spring existed prior to installation of the effluent application system. The flow is captured separately and piped below the effluent collection ditch, where it re-infiltrates the ground surface over a short distance (see Figures 9 to 11).

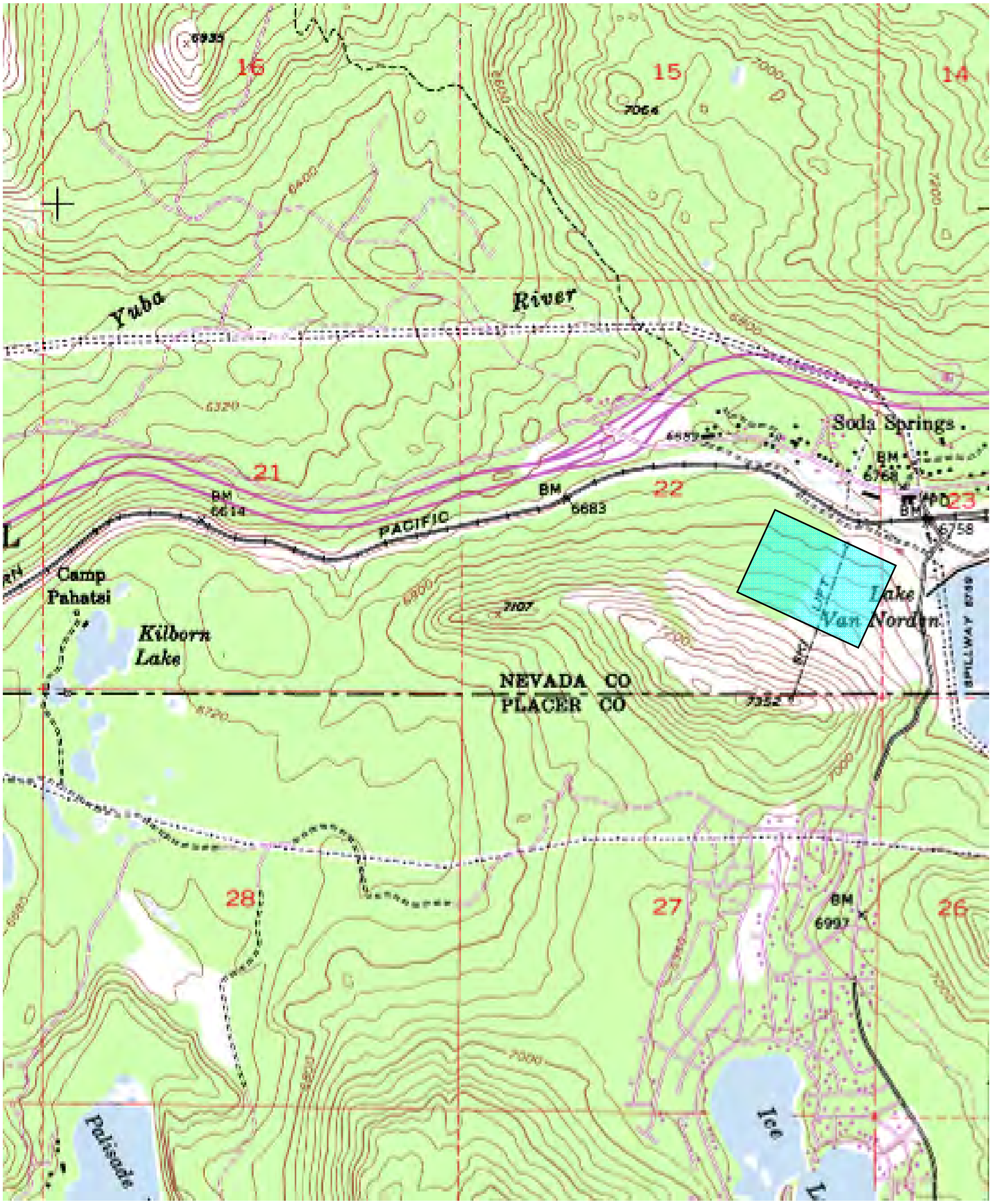

Figure 1
Topographic Map of Soda Springs Ski Hill
(Approximate location of the effluent irrigated area is shown in blue)

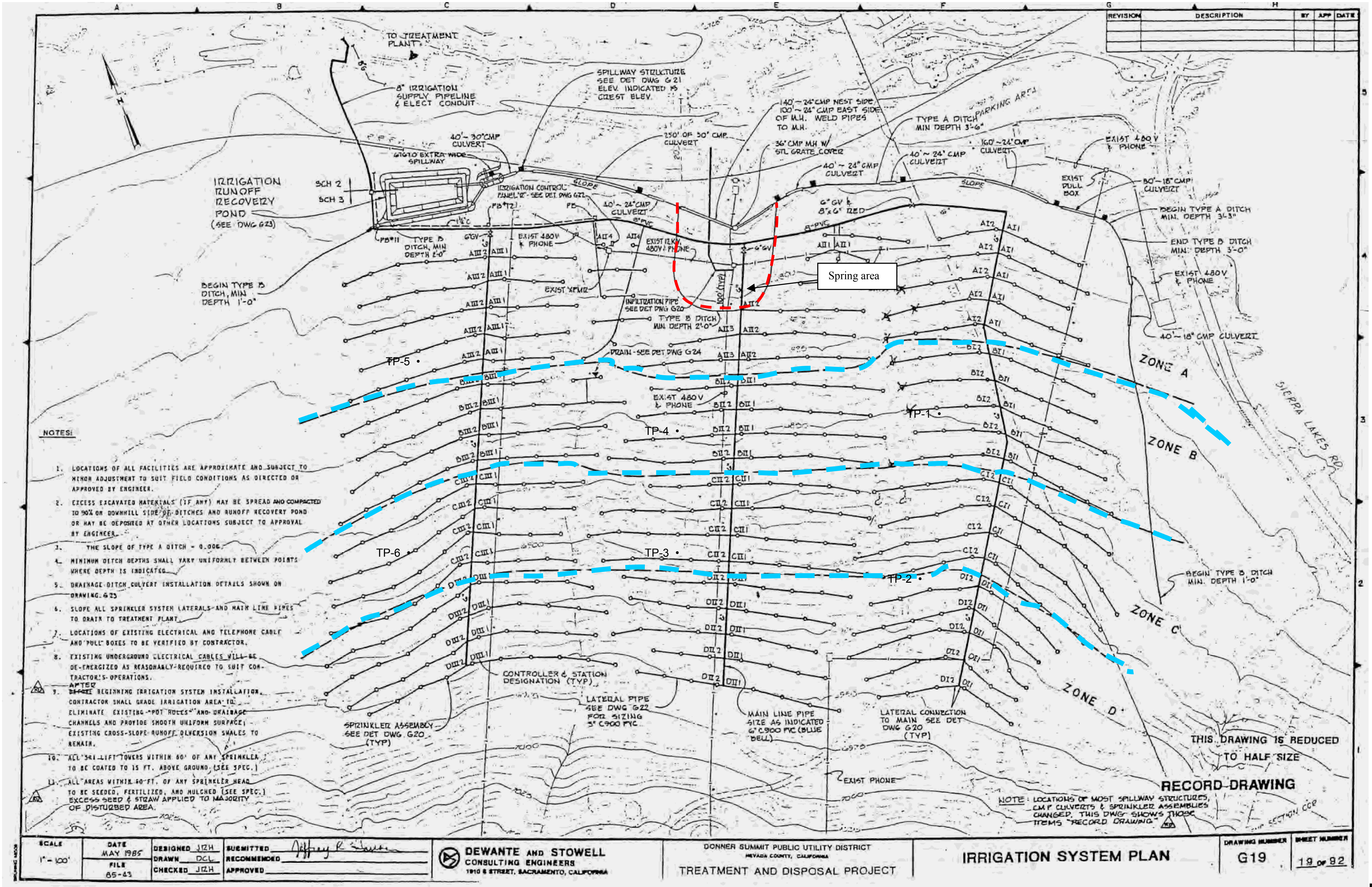

Figure 2
Topographic Map of Soda Springs Ski Hill Showing the Layout of Irrigation Pipe, Irrigation Zones and approximate Test Pit location (TP-1)

Figure 3
Aerial photograph of Soda Springs Ski Hill showing irrigated area (ski slopes with darker green color) and surrounding features.

Figure 4
View of Area I Looking South, Taken from Bottom of Zone A
(Irrigation Zone D starts at base of hill in background)

Figure 5
View of Runoff From Area I, Near Bottom of Zone B, Entering the Collection Ditch

Figure 6
View of Runoff Collection Ditch Looking East from Area I
(Note Adjacent Granitic Outwash)

Figure 7
View of Central Area II, Looking South from Zone A
(Irrigation begins near base of hill in background)

Figure 8
Runoff from Area II, Above the "Spring"

Figure 9
Wet Soil and Seepage from Spring Located Near Bottom of Area II, Zone A

Figure 10
View of Spring Discharge Near Base of Area II, Zone A
(Flow is less than 5 gpm)

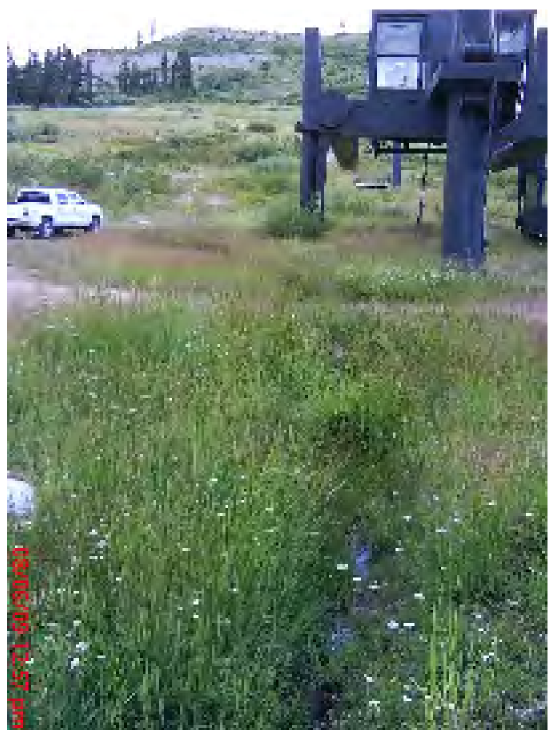

Figure 11
Spring Seepage Just Before it Enters Treeline at Base of Ski Hill

Figure 12
View of Western Application Zone III.
(Effluent is being applied near base of hill in background. No runoff was observed, although a small area of damp soils and willows is present below area being irrigated.)

Figure 13
Irrigation Runoff Recovery Pond Located in Northwest Corner of Property

Figure 14
View of Runoff Collection Ditch just Before it Enters Pond
(Gate allows Spring runoff of snowmelt to enter an ephemeral stream channel.)

3. HYDROGEOLOGIC SETTING

3.1 GEOLOGY

Area geology was mapped by both Hudson (1951) and Harwood (1980) (see Figures 15 and 16). Bedrock in the vicinity of the project consists of a sequence of relatively flat-lying volcanic rocks overlying older granitic rock (largely granodiorite). The volcanic sequence consists of a basal unit of rhyolite/dacite tuffs, overlain by andesitic flows and agglomerates, capped by basaltic flows and breccias that are usually only preserved along ridge tops. Because of erosion, faulting and the uneven granitic surface onto which the volcanic rocks were deposited, this sequence of volcanic rocks may be locally absent or incomplete.

Both geologic maps indicate that the rocks exposed at the top of the ski hill are basalt lava flows or intrusive breccias that belong to the youngest volcanic unit (see Figure 17). On the south side of the hill, the basalt is mapped as overlying the rhyolite tuffs, and the andesite unit is apparently absent (see Figure 18). On the north side of the ski hill, both the andesite and rhyolite tuff sequences appear to be absent, and the maps show the basalt in direct contact with the granitics, although the unit contacts are locally concealed by glacial deposits.

The basalts are relatively brittle and blocky, and they could be expected to have relatively high permeability. The underlying andesite agglomerates and rhyolite tuffs, if present, typically possess lower permeability. The older granitic basement rock is essentially impermeable unless fractured or faulted, in which case highly permeable zones of secondary porosity may be present.

Overlying the bedrock are Quaternary glacial deposits, including both moraines and outwash. Test pits completed midway on the ski hill in 1984 (see Section 3.2) indicated that the soil and outwash overlying the bedrock was two to five feet thick. One exposure of the glacial materials exists along the railroad tracks just north of the ski hill which indicates that the deposits thicken towards the river (see Figure 19). These materials can have variable permeability, depending on the amount of silt and clay in the matrix.

3.1.1 Structural Geology

Because the volcanic and granitic rocks are often brittle, faults can provide secondary porosity and pathways for groundwater flow. Neither the Hudson nor the Harwood maps identify any faults in the irrigated area of the ski hill, in part because bedrock underlying the ski hill is largely obscured by soil and/or glacial cover. No obvious linear features that could be interpreted as faults were observed in aerial photographs of the irrigated area. Hudson mapped a fault southeast of the ski hill, but it should not have any affect on groundwater in the irrigated area.

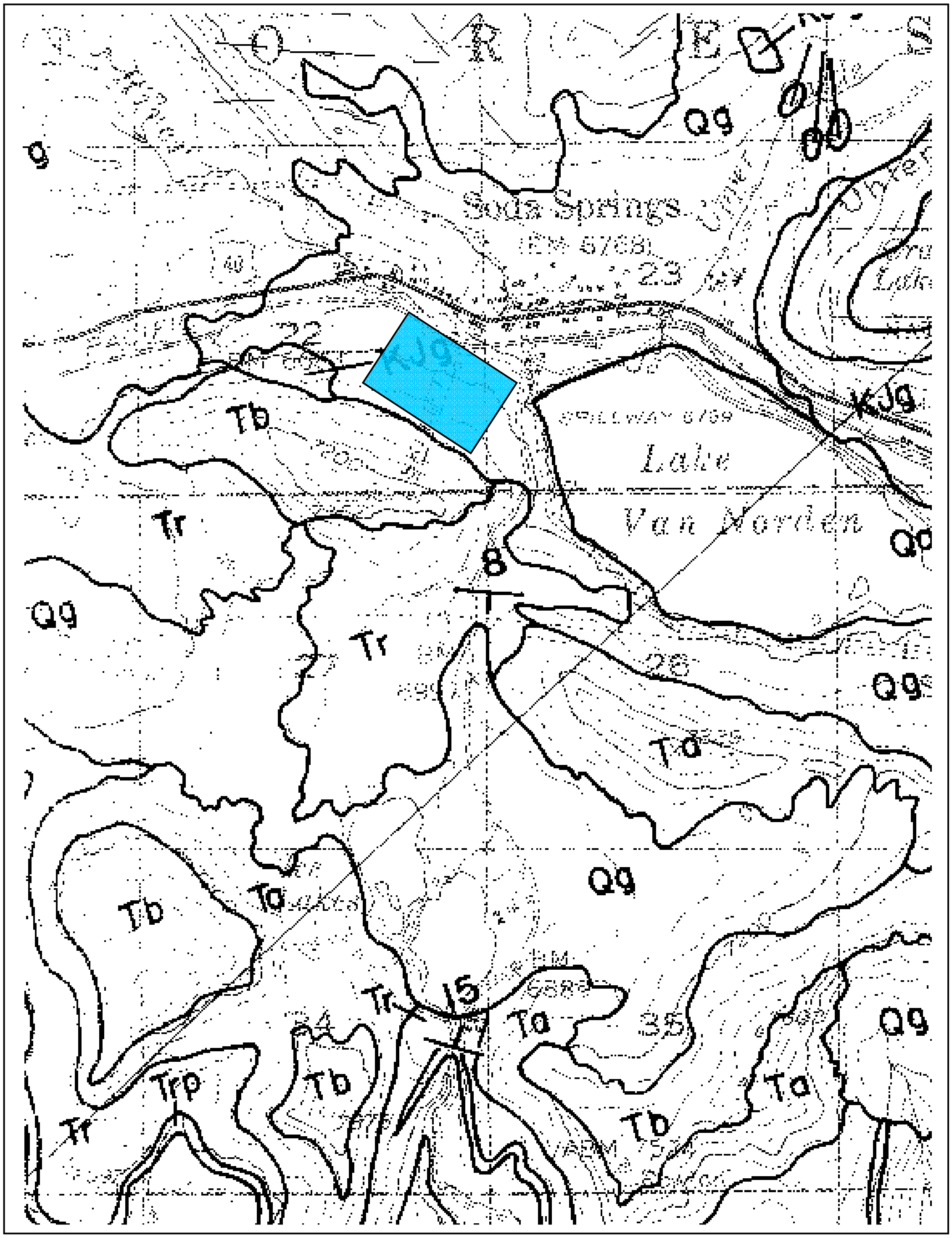

Figure 15
Harwood (1980) Geologic Map
(Irrigated area highlighted in blue.)

Qg=undifferentiated glacial deposits, includes till and outwash
Tb= basalt; Ta= andesite; Tr=rhyolite and dacite tuffs; KJg=granodiorite

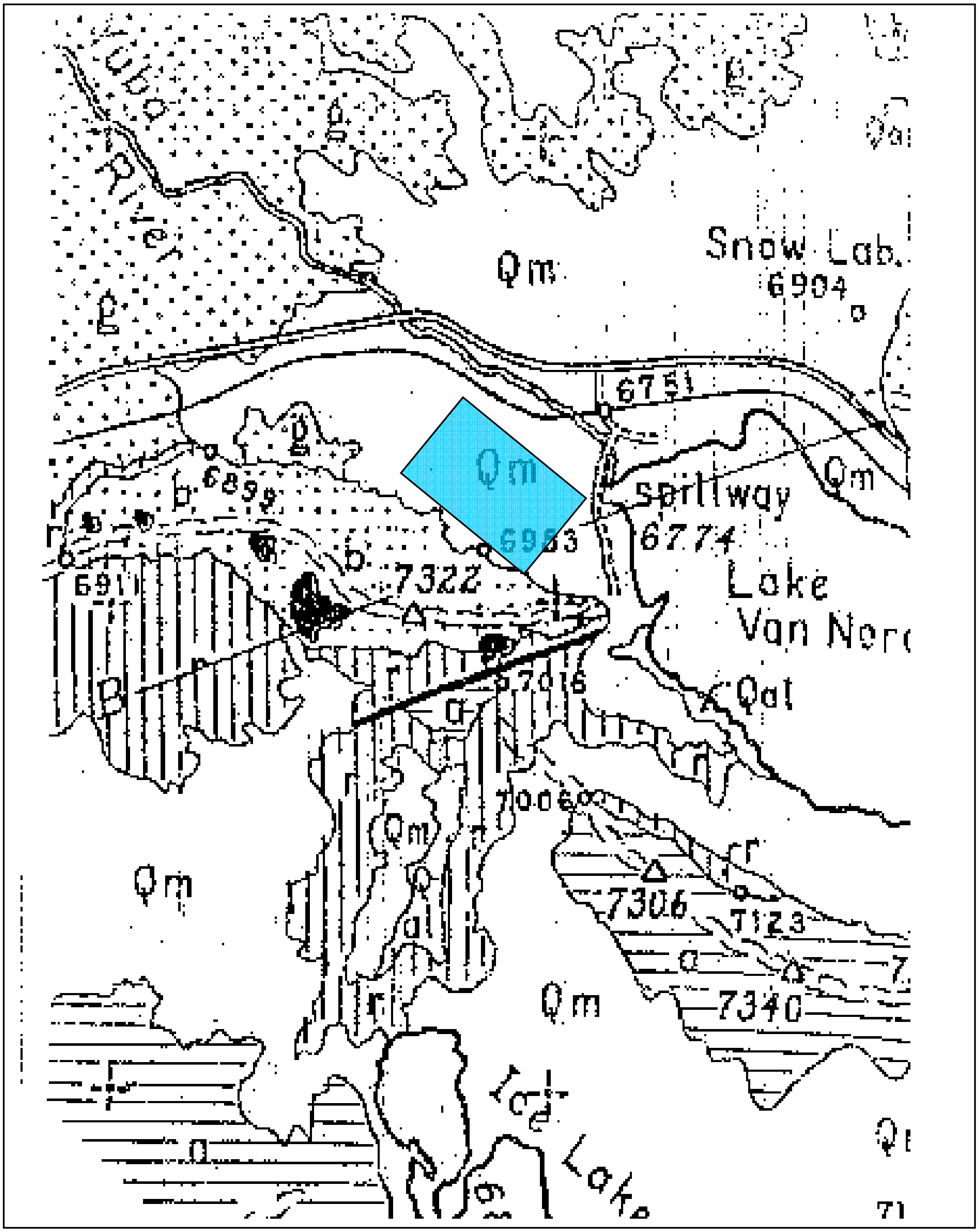

Figure 16
Hudson (1951) Geologic Map
(Irrigated area highlighted in blue.)

Qm = glacial deposits
b = basalt flows, agglomerates and tuff. Intrusive breccia and lava in black.
a = andesite agglomerate, minor tuff & flows
r = rhyolite tuff, in part welded
g = intrusive

Figure 17
View of Basalt Agglomerates Located Near East End of Top of Ski Hill
(Note large granite glacial erratic on top of basalts.)

Figure 18
View of Weathered Tuffs Overlain by Basalt
(Photo taken along road on east end of Hill. Andesite is apparently absent here.)

Figure 19
View of Glacial Moraine Deposits Located Next To Railroad Tracks
(Consists of angular granitic rock clasts in a dense, silty, sandy matrix. Permeability is likely fairly low. This exposure is located on the drainage which originates on the east side of the runoff recovery pond. Note the near-surface iron stain.)

3.2 SOILS

Prior to construction, Davis[2] Consulting Earth Scientists (1984) prepared a soils report for the effluent application area, and described the site soils as follows:

> *"Soils mapped by the USDA Forest Service, Tahoe National Forest, Order III Soil Resource Inventory, 1981, Soda Springs California, are Tallac Cryumbrepts, wet complex, 2 to 30% slopes (TBE), which are considered to be deep, moderately well drained soils on terminal glacial moraines and outwash, mixed with soils of variable depths, somewhat poorly or poorly drained, over impervious rock or cemented gravels."*

Davis[2] also completed six backhoe observation pits to characterize the soils, in the locations shown on Figure 2. Observations from the pits included the following (summarized):

> *'Data from six backhoe observation pits revealed fairly uniform soils ranging in depth from 24 to 60 inches over massive, hard, andesitic mudflow. The average soil depth was 31 inches.'*

> *"Surface stones and boulders…an obvious indication of glacial activity…are almost exclusively granitic…only a few were identified as volcanic. '*

> *'Textures range from light, fine sandy loams in the surface to very gravelly, light fine sandy loams in the subsoil. Drainage is characterized as moderately well drained over*

> *much of the site, and there are some areas that are somewhat poorly drained. Active seasonal groundwater was observed in pit No. 5 at 24 inches depth (other pit logs also indicated evidence of a shallow seasonal water table). Hydraulic conductivity of these soils is estimated to be moderate to high, and runoff is medium to rapid."*

The soils report in general indicated that the soil in the effluent application area is underlain by low-permeability andesite mudflows at shallow depth instead of either the basalts exposed above the irrigated area or the granitic basement. Seasonal groundwater was identified in three test pits at the contact between the soils and the mudflow surface at depths ranging from 24 to 38 inches. The glacial deposits on the slopes are apparently thin, but they may thicken down-slope, as illustrated in Figure 19 (an exposure of the glacial material adjacent to the railroad tracks).

3.3 GROUNDWATER

Despite the area's significant precipitation, there is no regional aquifer per se in the project vicinity because of the prevalence of low-permeability, or impermeable, bedrock which has little water storage capacity. Spring snowmelt results in heavy runoff to area streams that are either dry by mid summer or have greatly reduced flows. Area groundwater production is typically derived from shallow wells drilled in localized alluvial basins, or from wells that intersect discontinuous fractures or fault zones in the bedrock. Wells drilled in granite may be completely dry regardless of depth, unless they encounter open fracture zones. Similarly, area wells drilled in the volcanics (usually the rhyolite tuffs) typically do not produce significant groundwater outside of fracture zones, although because of their layered nature small amounts of groundwater may be produced from interflow zones. There are no mapped faults or fracture zones in the effluent irrigated area that would indicate the presence of groundwater resources in the underlying bedrock, or effect the direction of groundwater flow, although some could exist that are obscured by the soils and glacial cover.

There are no wells on the property, nor any within the strip of land between the ski hill and the South Yuba River. Because no wells are present on the property, the only known groundwater at the site is the shallow seasonal water present at the interface between the soils/glacial materials and the underlying bedrock. The flow direction of this perched groundwater presumably mimics the slope of the ground surface and moves northerly or northwesterly towards the South Yuba River. Under the irrigated area, it may be restricted to a shallow depth, as it locally surfaces near the base of the hill at the "spring area" shown on Figure 2. Closer to the river, the glacial deposits appear to thicken, and if this groundwater continues to move along the underlying bedrock surface, the upper surface of the groundwater would be at an elevation similar to that of water in the river.

3.3.1 Background Water Quality

No information is available on groundwater quality in the vicinity of the ski hill, and there are no analytical data for the spring discharge that occurs near the bottom of Area II. The closest domestic wells are located on the north side of South Yuba River. The closest municipal wells for which information is available are located about 0.75 miles south of the ski hill in the Ice (Serene) Lakes area. Two wells there are operated by the Sierra Lakes County Water District. Previous ECO:LOGIC communications with District personnel indicated that the wells were completed in fractured rock, and that one of the wells contains arsenic and manganese in concentrations greater than drinking water standards. Elevated iron concentrations are also reported to occur in some area wells.

3.4 SURFACE WATER

During the site visit in August, all ephemeral drainages near the property were dry, and the South Yuba River itself only contained small pools of nearly stagnant water (see Figures 20 to 23). At the spring near the bottom of Area II, an area of wet soils and minor seepage (flowing a few gallons per minute) was present (see Figures 9 to 11, and 24 to 26). This “spring water” was collected separately from effluent runoff and piped beyond the lower runoff collection ditch. There, it trickled across an overgrown dirt road (which follows a gas pipeline), present between the bottom of the ski hill and the railroad tracks (see Photograph 25), and re-infiltrated into the ground surface along the south side of the railroad tracks (see Photograph 26). North of this area along the railroad tracks, a thicket of willows is present near the river. Soils in the thicket were dry during the site visit. No other wet areas were observed anywhere down-gradient of the ski hill. No analysis of this “spring water” has been conducted to determine if it currently differs chemically from effluent.

The subsurface features that cause groundwater to surface in the spring area are unknown. No irrigation water is applied within 100 feet of the spring collection pipe. There are no obvious geologic or topographic features controlling the spring. The spring is located at the base of a shallow, broad drainage, or swale, in the hill slope that has vegetation patterns (see Figure 3) suggesting Area II has a somewhat more developed watershed than Areas I and III. It is possible that the soils are slightly thicker in this area and retain snow melt slightly longer than other areas of the hillside. The swale may act to collects the shallow groundwater moving along the outwash/bedrock interface, and the spring discharge may occur because of an underlying change in geology, a local thinning of the glacial outwash, or shallowing of the underlying, low-permeability bedrock.

Figure 20
Dry Runoff Channel Located on West Side of Middle Field Taken Above Pipeline Road, Looking South (about 100 feet west of the spring area) ***(Channel receives runoff from snowmelt or large storm events. Note granite outwash/till)***

Figure 21
Dry Channel Located Below the End of the Runoff Collection Ditch Near The Pond
(Notice iron-oxide stained rock)

Figure 22
View of Dry Stream Channel On Far West Side of Property Showing Typical Granitic Glacial Materials In Dry Channel
(Not as much iron stain, here, as in Figure 24)

Figure 23
View of South Yuba river directly north of property
(water was essentially stagnant)

Figure 24
Trickle of Water From "Infiltration Pipe" Below Main Chair Lift

Figure 25
View of Spring Seepage on Pipeline Access Road Just Below Ski Slopes
(The flow appeared to be only one to two gpm.)

Figure 26
All Seepage Appears To Infiltrate Along The Railroad Tracks

4. CONCLUSIONS AND RECOMMENDATIONS

Based on the results of soil test pits completed along the middle of the ski hill, the geology of the Soda Springs effluent irrigation area consists of a relatively thin layer of soil and glacial materials, overlying andesitic agglomerates. The depth to granitic bedrock is unknown. The soils/glacial materials are two to five feet thick in the central portion of the ski hill, but may thicken down-slope towards the river. A regional groundwater aquifer is not present; and due to the anticipated low permeability of the agglomerates, it is uncertain if any significant groundwater would exist below the soil/agglomerate interface.

The area receives significant precipitation, mostly as snow. Spring snowmelt forms a seasonal perched water table at the interface of the soil/glacial materials and the underlying volcanic agglomerates. The bulk of this seasonal perched water table drains away quickly each spring as evidenced by area stream channels and the South Yuba River being mostly dry by mid-summer. As a result of substantial amounts of snowmelt filling and then draining away from these shallow soils each spring, it is believed that accumulation of effluent residuals (such as salts) in the soil is prevented.

The purpose of this study was to "evaluate the most effective means of monitoring groundwater in the land application area, and address the feasibility of installing monitoring wells in regards to the slope of the terrain on the land application area, the soils and subsurface geology in the area, and any other criteria applicable to the monitoring of groundwater in the land disposal area."

Based on the results of this assessment, ECO:LOGIC recommends a phased approach to evaluating the potential for groundwater impacts, as follows:

1. Because effluent naturally contains more stable residuals than snowmelt, some degradation of seasonally perched shallow groundwater is expected. This degradation should be acceptable under Resolution No. 68-16, the Anti-Degradation Policy (Policy), as long as:

    a. A water quality objective (WQO) is not being exceeded; and,

    b. The District is implementing Best Practicable Treatment and Control (BPTC) measures to reduce degradation to the extent feasible within the context of the Policy.

    Because some degradation is expected, a "background well" is not needed in general. This is because once degradation is acknowledged as occurring to some extent, the remaining issues are whether a WQO is begin exceeded, and whether BPTC measures are being implemented. A background well should be needed only if a WQO is being exceeded in a well downgradient from the effluent application area. In that case, a background well could demonstrate whether that WQO exceedance is natural (and therefore acceptable), or caused by the effluent application (which would be unacceptable). As noted earlier, it is known that area groundwater can naturally exceed some WQOs, such as for arsenic and manganese.

2. The seasonal flushing of these shallow soils by substantial snowmelt each spring should prevent accumulation of effluent residuals in these soils over time, i.e., results from groundwater quality monitoring should not vary significantly from year-to-year (though quality may vary considerably within a year) as long as effluent quality and effluent disposal practices do not vary significantly from year-to-year.

3. There are no wells or groundwater users between the ski slopes and the South Yuba River, and there are no analytical data available to determine if the spring seepage currently contains a significant component of effluent. Since the spring appears to originate from the swale comprising Area II, it would be expected to contain some effluent residuals, particularly in late summer and early autumn prior to the flushing of these shallow soils by snowmelt in the following spring. A sample of the spring water should be collected at the end of an effluent irrigation season when effluent impacts on this perched groundwater are most likely to be evident, and analyzed. If the results are not indicative of effluent, it would be difficult to conceive of effluent impacts to deep or shallow perched groundwater.

4. If the "spring water" sample is indicative of containing significant amounts of effluent residuals, other groundwater impacts are conceivable, at least to seasonal, shallow perched groundwater. Because of the large flux of snowmelt through the site, water levels and impacts would likely vary considerably throughout the year. Wells that could monitor seasonal changes in the quality of shallow groundwater migrating along the soil/bedrock interface could be installed anywhere along the dirt road that runs along the base of the ski hill, provided they are installed in areas that would not interfere with ski operations. A proposed site near the center of the application area is shown on Figure 3. Groundwater would be expected to occur at shallow depth in this area because of the proximity of the springs. The well should extend through the glacial materials and several feet into the underlying bedrock, or several feet into the water table. Because this site is centrally located, it would be downgradient of the application areas even if there is an east-west component to shallow groundwater flow.

5. If a "background" water quality sample is desired, it would have to be collected in an area of the property that is not impacted by the effluent application, which will be difficult given the property configuration and the distribution of effluent across most accessible portions of the ski hill. Ideally, the groundwater to be sampled would be either from the South Yuba River drainage upgradient of the application area, or west (cross-gradient) of the application area and at the base of the hillslope. Groundwater from these areas would reflect the natural accumulation of salts and other contaminants as snowmelt reacts with the local geology and picks up materials from decaying vegetation and low redox bog conditions existing in the area.

   Considering area topography and reasonable deductions regarding seasonal shallow groundwater movement over underlying bedrock, a credible background monitoring well site, if requested, could be located near the entrance to the parking lot on the east side of the property, just below the Lake Van Norden outlet (see Figure 3). Given the higher elevation of Lake Van Norden, it is assumed that the groundwater flowing through this site would be moving westerly, and thus would not be impacted by effluent application uphill in Area I. However, if effluent moves directly downhill from Area I (instead of more northwesterly as anticipated), it is possible that this site could be influenced by effluent. If sample results indicate an impact, a second "background" well could be installed on the west side of the property, preferably several hundred feet west of the Irrigation Runoff Recovery Pond. However, there is currently limited access to the area west of the runoff recovery pond and groundwater near the pond may be affected by effluent application in Area III. .

   Seasonal water quality testing of the wells would provide information about the timing and extent of shallow groundwater degradation, if any, or possible pollution (i.e., an exceedance of a water quality objective) caused by effluent application practices. Given that the area soils drain rapidly after snowmelt is completed, it is possible that the background well, regardless of location, would be dry by late summer. The background well location just below the Lake Van Norden outlet is least likely to be dry by late summer.

6. If the results of water quality analyses indicate an exceedance of a water quality objective, additional wells can be installed, as necessary, along the ski hill's lower dirt road to better quantify the groundwater flow direction and the total area of impacted groundwater. However, because of the petroleum pipeline, railroad tracks, and rough bouldery terrain located between the ski slopes and the river, it would be difficult to install additional groundwater monitoring wells closer to the river.
7. Installing deep monitoring wells within the underlying bedrock does not appear to be warranted at this time because it is anticipated to have very low permeability.

5. REFERENCES

Davis[2] Consulting Earth Scientists, 1984: Soda Springs Ski Slope Soils Study. Unpublished report prepared for Dewante and Stowell Consulting Engineers, dated December 1984.

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