CDM Smith

Memorandum

To: *Erica Kidd, Watershed Manager*

From: *Robert H. Fitzgerald, PE, Water Resources Engineer*
Anne E. Malenfant, PE, PMP, Project Manager

Date: *June 24, 2022 (Draft)*
October 5, 2022 (Revised)

Subject: *Watershed Delineation Rezoning Review – Gravel Pit Parcel*
Lake Auburn Watershed Protection Commission

Executive Summary

As part of an environmental and regulatory analysis of Lake Auburn water supply protection (FB Environmental, 2021), a revised delineation of the watershed near the southeast shore of Lake Auburn was presented which reduced the watershed area by 148 acres. This revised watershed delineation in part reflects topography (i.e., surface drainage) and in part was based on estimates of groundwater flow directions presented in previous hydrogeologic studies.

The Lake Auburn Watershed Protection Commission requested CDM Smith to provide an independent review of the past studies that were the basis of this revised delineation, including the geologic, water level and water quality data and analyses presented in these reports. CDM Smith's observations and assessments pertinent to watershed delineation are presented in the following memorandum.

Based on CDM Smith's review, the groundwater data support the revised watershed delineation in some areas, and in other areas the data are insufficient to confirm a precise delineation. **Figure ES-1** presents a summary of the review, including the revised delineation (red dashed line), the area of uncertainty (blue dashed line) and direction of groundwater flow (blue arrows), and can be summarized as follows:

- The solid blue line to the west is a delineation that reflects surface topography and is consistent with the FB Environmental revised delineation except for a small area to the north near MW-1 and MW-4. To the south of this line, data from 14 groundwater monitoring wells indicate flow in the surficial sand and gravel away from the lake and, significantly, groundwater levels that are below lake level, precluding discharge to the lake.
- Near the center of **Figure ES-1** are three triangles indicating the location and elevation of bedrock outcrops. In this area of high bedrock (so called "bedrock knob"), the water table is

in bedrock and is above lake level based on surrounding well data. However, in the reviewed reports there is no well data to indicate bedrock flow direction in this area. Hence, **Figure ES-1** indicates a band of uncertainty in the area of the outcrops and nearby topographic high elevations.

- To the east of the bedrock knob, water level data from wells MW-1, MW-10, MW-301 and MW-206 indicate a water table in the sand and gravel above lake level with a generally northeastward flow direction. Groundwater within the band of uncertainty in this area could possibly discharge to Lake Auburn or to a stream farther to the east that is tributary to the Androscoggin River.
- The northern limit of the uncertainty band in **Figure ES-1** is approximately consistent with a surface drainage divide indicated by topography. To the south of the uncertainty band, water level data (and also water quality data) indicate that the water table is in the surficial sand and gravel with a flow direction away from the lake. This includes data from wells MW/PZ-203, P-1, MW-205, MW-102/P-2 and MW-101/P-3.

To determine the limit of the watershed in this "area of uncertainty", the following steps would be recommended:

- Create a 3-D geometric visualization model and associated geographic information system (GIS). The scope of effort would include:
  - Incorporation and integration all of the relevant geologic, well construction, water level and water quality data included in the reports that were reviewed.
  - Additional data including topography, land parcels and other geographic features.
  - Research to identify if there are other hydrogeologic data available not included in the reports reviewed for this memo. These might include additional seismic survey results and boring logs.
- Based on the visualization model, the need for and focus of additional field data collection and/or groundwater flow modeling can be assessed. While it is likely that additional field exploration, including installation of new monitoring wells, will be required to more precisely delineate the watershed, preliminary visualization and modeling analysis can make this investigation more efficient.

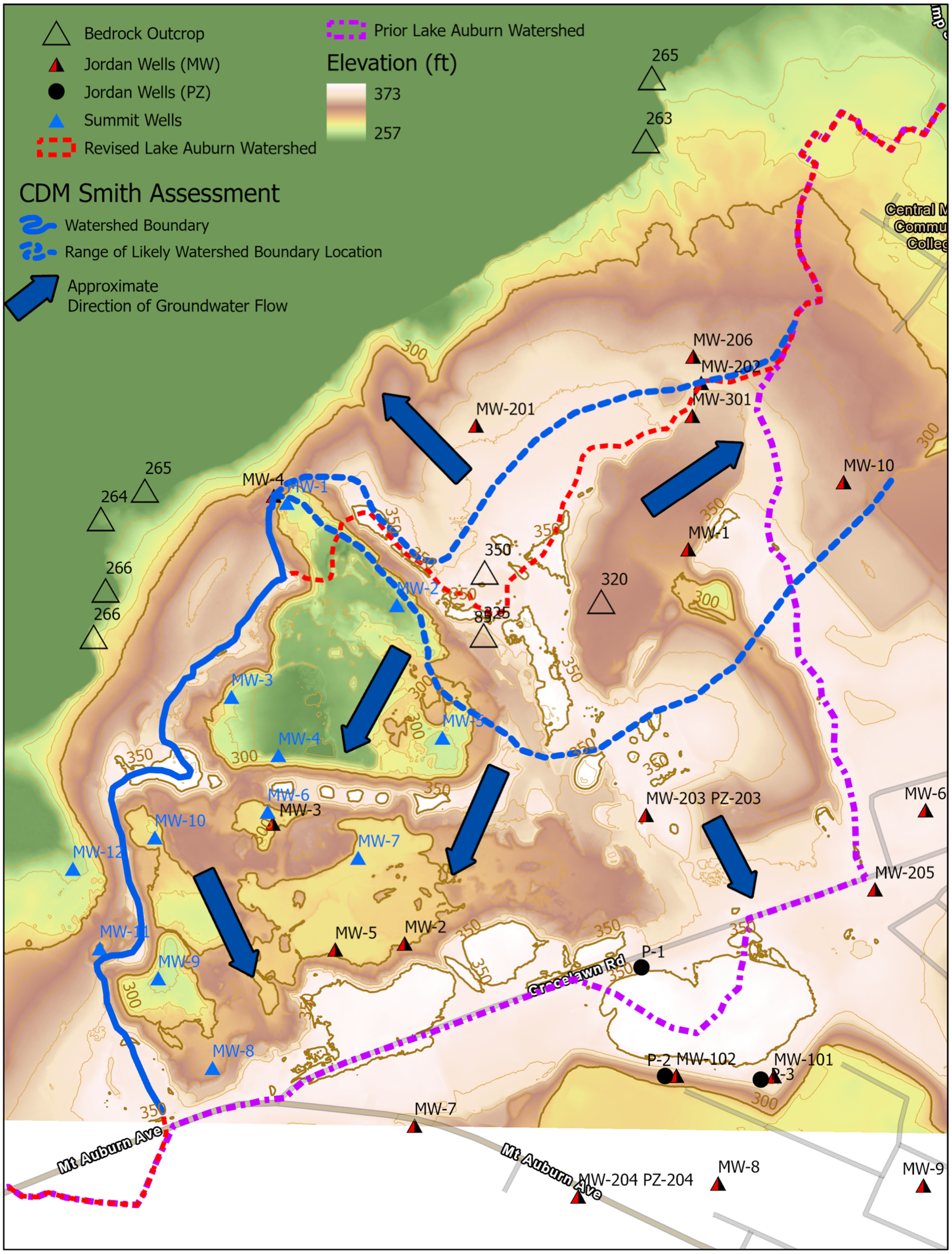


Figure ES-1: Summary of Estimated Watershed Boundary Review

Technical Analysis

Study Area Introduction

Lake Auburn in Auburn, Maine provides public drinking water supply to Auburn and Lewiston, Maine. As part of the report "A Regulatory, Environmental, and Economic Analysis of Water Supply Protection in Auburn, Maine" (FB Environmental, 2021), a revision to the watershed delineation near the southeast shore of the lake was presented. This revision was based in part on previous hydrogeologic studies:

- E.C. Jordan Co., Hydrogeologic Investigation, Gracelawn Landfill/Lake Auburn, June 1990. (E.C. Jordan, 1990)
- Woodard and Curran Environmental Services, Supplemental Hydrogeological Study, Auburn Brush Dump, City of Auburn, ME, August 1995. (Woodard and Curran, 1995)
- Summit Environmental Consultants Inc., Ground Water Assessment, Gracelawn Road Gravel Pit, Auburn, ME, September 2007. (Summit, 2007)

The watershed delineation was moved northward, closer to the lake, removing approximately 148 acres from the estimated watershed. **Figure 1** shows the previous and revised delineations as presented by FB Environmental. **Figure 2** shows an approximation of these delineations sketched onto an aerial photo. The area between the old and proposed new delineations includes a number of sand and gravel borrow areas on the west side and former City of Auburn landfill and dump areas to the southeast

The recently proposed City of Auburn land use zoning change for this parcel is generally consistent with the revised watershed delineation, as shown in **Figure 3**. The area within the newly delineated watershed is generally shown to be in a "Resource Protection" zone, while much of the area just outside of the revised delineation is shown to be in a "General Business" zone.

This memo presents a review of the data presented in the hydrogeologic reports listed above that formed part of the basis for the new watershed delineation, plus a Maine DEP (MEDEP, 2019) memo related to the Gracelawn Landfill near the southern boundary of the study area.

- State of Maine Department of Environmental Protection, June 3 2019 Memorandum, Site: Gracelawn Landfill, Auburn, Subject Document: 2018 Annual Monitoring Report, Gracelawn Landfill, Auburn, ME prepared by CES Inc.

Study Area Topography

Topography and surface water drainage were not addressed in the reports reviewed for this memorandum. However, it is evident in **Figure 4** that topography was a significant factor in developing the revised watershed delineation. That is, the revised delineation in large part follows local topographic high points. Apparent exceptions are circled in **Figure 4**. The delineation does not follow the topographic high to the north near Summit well MW-1 and Jordan well MW-4, and does not extend south to the apparent topographic high between the bedrock outcrops labeled 325 and 320 (indicating surface elevation).

Study Area Geology

Sand and Gravel Overburden

According to E.C. Jordan (1990), the overburden soils are primarily ice-contact deposits, which "consist largely of stratified water-laid, medium to fine sands. Widespread coarser deposits of sand, gravel, cobbles, and boulders are present at the surface (topset beds) across much of the site but only locally with depth." The sand and gravel deposits are noted to be 50 to 150 feet thick where borrow pits have been excavated.

Glacial Till

According to Jordan, a layer of till underlies the sand and gravel and overlies the bedrock. The till is described as "a very dense, heterogeneous, unstratified mixture of silt, clay, sand, gravel, cobbles, and boulders." As such, the till, where it exists, could act as a semi-confining layer inhibiting groundwater flow.

The presence of till is explicitly recorded in logs of borings that were continued into bedrock as rock cores. Till is not explicitly identified in boring logs of wells completed in the overburden. The till layer is noted by Jordan to be relatively thin, with a maximum observed thickness of 7.5 feet.

Bedrock

The overburden and till are underlain by bedrock. The bedrock is visually identified in rock cores as coarse-grained gneiss. A few areas where the bedrock is present at the ground surface (outcrops) have been observed near the center of the study area and at/near the lake shoreline.

The bedrock is considered to be water bearing; a few of the groundwater monitoring wells were completed in the bedrock. No estimate of the permeability or transmissivity (i.e. quantity of groundwater flow the bedrock can support) is provided.

Bedrock Surface Geometry

Groundwater flow in the sand and gravel overburden is influenced in part by the geometry of the bedrock (plus till layer) that underlie the sand and gravel overburden and define the limits of the overburden aquifer.

Figures 5 and **6** show bedrock surface contours as presented by E.C. Jordan (1990) and Woodard and Curran (1995), respectively. In **Figure 6**, bedrock surface contours are shown only for the northeast part of the study area (orange circle). Seismic survey lines in that area are also shown. The contours in both figures were developed based on seismic surveys, boring logs and surveyed elevations of outcrops. Though it is not stated how the thin till layer might affect the seismic data and refusal in borings, the delineated bedrock surface should be reasonably representative of the bottom of the sand and gravel overburden aquifer, except at the identified outcrops areas where the overburden aquifer does not exist.

Noteworthy features of the delineated bedrock surface geometry include the following:

Knob

- Near the center of the study area is an area of high bedrock, labeled "bedrock knob" in **Figure 5**. The area includes outcrops, indicated by triangles in the original figure, circled in red in **Figure 5**. Outcrop surface elevations of 350, 325 and 320 feet mean sea level (MSL) are shown. The reported bedrock surface at MW-201, just north of the outcrops, is also greater than 300 feet.

- The bedrock surface appears to decline most steeply from the "knob" area to the north and northwest towards the lake, and to the southwest.

West/Southwest

- A large area with bedrock elevation less than 250 feet MSL is indicated for the west/southwest portion of the study area by E.C. Jordan (1990).

- This is consistent with well data presented in the Summit (2007) report for this area. While top of bedrock/till, or refusal is not explicitly stated in the logs, the bottom elevations of all but two of the twelve Summit overburden monitoring wells are below 253 feet MSL.

- The eastern-most Summit wells, MW-2 and MW-5, have bottom elevations greater than 260 feet MSL, indicating where bedrock starts to rise towards the "knob". (The Summit report refers to a seismic survey performed, but no data from the survey are provided.)

- Bedrock outcrops at the shoreline with surface elevations 264-266 feet MSL shown in **Figure 3** indicate a rise of the bedrock surface near the shore. The relatively elevated bedrock here might significantly limit the hydraulic connection between the overburden aquifer and the lake, which has a water surface elevation of approximately 260 feet MSL.

South/Southeast

- The bedrock surface decline to the south and southeast of the knob is less steep. The bedrock surface at MW-203, approximately 900 feet to the south-southeast, is 283 feet MSL. At MW-6, approximately 1,500 feet southeast, the bedrock surface indicated by refusal is 277 feet MSL.

East/Northeast

- **Figure 6** shows bedrock surface elevation contours for this area presented by Woodard and Curran (1995). These are based on boring logs and the seismic survey. The contours indicate the bedrock surface is lower than 250 (and as low as 235) feet MSL at MW-202, MW-206 and MW-301, approximately 900 feet east of the knob, indicating a significant decline.

- The contours indicate a subsequent rise in the bedrock surface to elevations greater than 260 feet MSL farther to the northeast.

- Note that the contouring shown in **Figure 6** does not account for the higher bedrock surface estimated at MW-1, approximately 500 feet south of MW-301, to be 275 feet MSL.

- The green circle at the eastern edge of **Figure 6** highlights locations where the topographic contours indicate areas where the ground surface is less than 260 feet. The area is highlighted in **Figure 6** because subsequent figures in this report do not extend that far to the east.

Groundwater Flow

The following observations about likely groundwater flow features in the study area are made based on data presented in the reports reviewed for this memo. The observations are made in the context of estimating the Lake Auburn watershed area, noting that precise new delineations have not been made as part of this review task.

The discussion below is organized by subareas that share similar groundwater flow characteristics that are distinct from the other subareas. The subareas are defined and illustrated by the locations of representative monitoring wells or bedrock outcrops.

A. Lake Auburn

- The lake water level is controlled by a dam. Based on 1940-2012 data, the lake level averages approximately 259.9 feet MSL, with a range from approximately 257 to 262 feet MSL.

- Groundwater level probes installed 2 to 4 feet into the lake bottom sediments just offshore (**Figure 7**) indicated upward head gradients, i.e., groundwater flow into the lake, at 10 of the 12 working probes. (DP-10 was damaged.)

- A slight downward gradient was observed at DP-13 adjacent to the wetlands near the northwestern extent of the study area. DP-2, near the northeastern extent of the study area also indicated a downward gradient.

- The observation of bedrock outcrops near the shoreline suggests that the bedrock aquifer could be a source of groundwater discharging into the lake.

- While the measured gradients in the probes were substantial, up to 1 foot head difference, the rate of groundwater flow into the lake at the probe locations depends on the degree of flow resistance provided by the bottom sediments. No hydraulic conductivity estimates were included in the reports.

B. North Central (Knob Area)

- Three identified bedrock outcrops near the top of the bedrock “knob” are circled in **Figure 8**. Also circled is well MW-201, approximately 600 feet north of the outcrops. The water table is in the bedrock at MW-201. Hence, most or all groundwater flow in this subarea is within the bedrock.

- The measured water level in MW-201 is greater than 305 feet MSL, and is thus more than 40 feet above the lake water level.

- The groundwater level could be even higher near the outcrops, where the surface elevation is higher than at MW-201 and the bedrock aquifer is directly recharged.

- While there is insufficient data to reliably determine bedrock groundwater flow direction in this subarea, it is very possible that this flow is to the lake. This includes the outcrop area, some of which appears to be outside of the revised watershed delineation.

C. West-Southwest

- Measured groundwater levels are below lake level (250.0 to 255.2 feet on 5/24/1990) in E.C. Jordan overburden monitoring wells MW-2 – MW-5.

- Summit overburden monitoring wells in the same area, MW-1, MW-3, MW-4, MW-6 – MW-12, also had water levels below lake level (250.6 to 258.0 feet MSL on 5/15/2006 to 8/9/2007)

- Hence, overburden groundwater flow in the area represented by these 14 wells (indicated by solid green circles in **Figure 9**) does not discharge to the lake based on these data. A mild southerly gradient away from the lake is indicated for both sets of wells.

- These data consistent with the revised watershed delineation in this subarea, except that Jordan well MW-4 and Summit well MW-1, which are part of the group with water levels below lake level, are within the revised watershed.

- Data for the easternmost Summit wells, MW-2 and MW-5 (dashed green circles in **Figure 9**), indicate that both the bedrock surface and groundwater levels exceed the lake water level (maximum reported groundwater level 271 at MW-5).

- The ground surface and bedrock surface rise steeply to the knob east and northeast of MW-2 and MW-5. Hence, these wells are likely close to the northeastern limit of the area where groundwater flow is predominantly in the overburden and is reliably away from the lake. At both wells, the measured water level is near the bottom of the well, assumed to be at or near the bedrock or till surface.

- The lake sediment probe data suggests that lake water does not contribute significantly to overburden groundwater flow in this subarea. This is consistent with high bedrock observed near the lake shore that could limit the hydraulic connection between the lake and the overburden aquifer.

- No data are available to indicate whether bedrock flow in this subarea could discharge to the lake, thus causing the observed upward gradients in the lake sediments. However, even If the bedrock aquifer does discharge to the lake in this area, the bedrock aquifer could not in that case be recharged in this subarea where overburden heads are below lake level.

D. Southeast

- Southerly flow away from the Lake is indicated in the vicinity of the Gracelawn Landfill by groundwater levels measured at piezometers P-1, to the north, and P-2 and P-3 to the south of the landfill. The piezometer locations are circled in **Figure 10**.

- Southerly flow at the Gracelawn Landfill is also indicated by water quality sampling and analysis at wells MW-101 and MW-102, co-located with the piezometers south of the landfill. Elevated specific conductance (among other parameters) was reported for MW-101 and MW-10 by E.C. Jordan (1990) and for MW-101 by ME DEP (2019).

- To the north of the Graceland landfill approximately 600 feet, the water level at PZ-203 (289 to 293) is much higher than the water levels at the nearest wells to the south, southwest and southeast. It is likely, therefore, that groundwater flow from this location (dashed green circle in **Figure 10**) has a southerly component away from the lake, which is nearly one-half mile to the north.

- However, it is difficult to estimate the actual groundwater flow directions in this vicinity because it is significantly influenced by the high bedrock and till here. The measured water table at PZ/MW-203 is very near the top of till elevation, sometimes just above and sometimes just below.

E. Northeast

- Monitoring wells MW-1, MW-10, MW-202, MW-206 and MW-301 (indicated by orange circles in **Figure 11**) are located east of the area of highest bedrock associated with the "knob".

- A northward component to overburden groundwater flow is indicated by water levels measured by Woodard & Curran (1995) at MW-1 (278.7), MW-301 (275.5) and MW-206 (274.4). Synoptic data including these wells and MW-202 are not available.

- Approximately 600 feet farther east, the water level measured at MW-10 (272.7) indicates that there is also an eastern component to the groundwater flow.

- Woodard and Curran (1995) states, based on water quality data (not presented), that "it is possible that impacted groundwater from the north end of the brush dump and old burn area is flowing toward MW-10." This is consistent with both northward and eastward components to groundwater flow in this area.

- Lake Auburn (water level 260) and a stream channel east of MW-10, where ground surface is less than 260, are both possible points of discharge for groundwater in this area. The stream channel is tributary to the Androscoggin River.

- There is insufficient data to delineate a dividing line between flow to the lake and flow to the creek. One unknown is the influence (if any) on groundwater flow of the bedrock surface which rises to the east and north of MW-206 and MW-301.

Summary and Conclusions

As part of an environmental and regulatory analysis of Lake Auburn water supply protection (FB Environmental, 2021), a revised watershed delineation of the watershed near the southeast shore of the lake was presented which reduced the watershed area by 148 acres (**Figure 1**).

Lake Auburn is an unfiltered water supply source for the cities of Auburn and Lewiston, Maine. Hence, changes to the watershed delineation could be relevant to future land use and land use regulation and possible impacts on water quality.

The watershed revision was based in part on estimates of groundwater flow directions presented in previous hydrogeologic studies. CDM Smith reviewed the geologic, water level and water quality data and analyses presented in these reports. CDM Smith's observations and assessments pertinent to watershed delineation are presented in this memorandum.

The observations are organized in terms of subareas that share similar groundwater flow characteristics that are distinct from the other subareas.

Bedrock High (North Central)

Near the center of the area where the watershed delineation has been revised (study area), the bedrock surface rises, creating what is called a bedrock "knob". Groundwater flow here occurs only in bedrock. The bedrock groundwater level well MW-201 in this subarea is more than 40 feet above the lake surface water level and the groundwater level could be higher still near the bedrock outcrops farther to the south. Well MW-201 and the outcrops are circled in red in **Figure 12**.

There are insufficient data to reliably determine bedrock aquifer flow directions, but it would be reasonable to extend the revised watershed farther south in this area, to at least include the observed outcrop areas where the bedrock aquifer would be directly recharged as well as the nearby topographic high.

West-Southwest

To the west and southwest of the bedrock knob is a subarea represented by 14 monitoring wells (solid green circles in **Figure 12**) where the overburden groundwater level measurements are consistently below the lake surface water level. Groundwater in the area represented by these wells does not discharge to the lake. This is consistent with the revised watershed delineation, except that two of the wells in this group are north of the revised watershed delineation as shown in **Figure 12**.

Summit Environmental well MW-2 and MW-5 (Dashed green circles in **Figure 12**) are likely near the limit of the west-southwest subarea where groundwater flow is predictably away from the lake. Just to the northeast of these wells the ground surface and bedrock surface rise steeply towards the knob area.

Gracelawn Landfill (Southeast)

The previous watershed delineation apparently included the Gracelawn Landfill near it's southeastern limit. Groundwater level and water quality data at wells circled in blue in **Figure 12** indicate that groundwater flow in this vicinity is southward, away from the lake. This is consistent with the revised watershed delineation.

Northeast

Groundwater in the area indicated by the orange circled wells east of the knob in **Figure 12** likely flows in part to Lake Auburn and in part to a small stream just east of the study area that is ultimately tributary to the Androscoggin River. Data in the review documents, are not sufficient to precisely locate the divide between groundwater flow to the lake and to the river, and thereby establish a precise watershed boundary.

Further Study

If a more precise delineation of the watershed is required in any area, the next step would be to create a 3-D geometric visualization model and associated geographic information system (GIS) incorporating and integrating all of the relevant geologic, well construction, water level and water quality data included in the reports that were reviewed. Additional data including topography, land parcels and other geographic features should also be included. Research to identify if there are other hydrogeologic data available not included in the reports reviewed for this memo that should be included in the visualization model. These might include additional seismic survey results and boring logs.

Subsequently, the need for and focus of additional field data collection and/or groundwater flow modeling can be assessed. Groundwater flow model development would be significantly expedited by previous completion the 3-D geologic visualization model.

Attachment

Technical Memorandum Figures

Figures

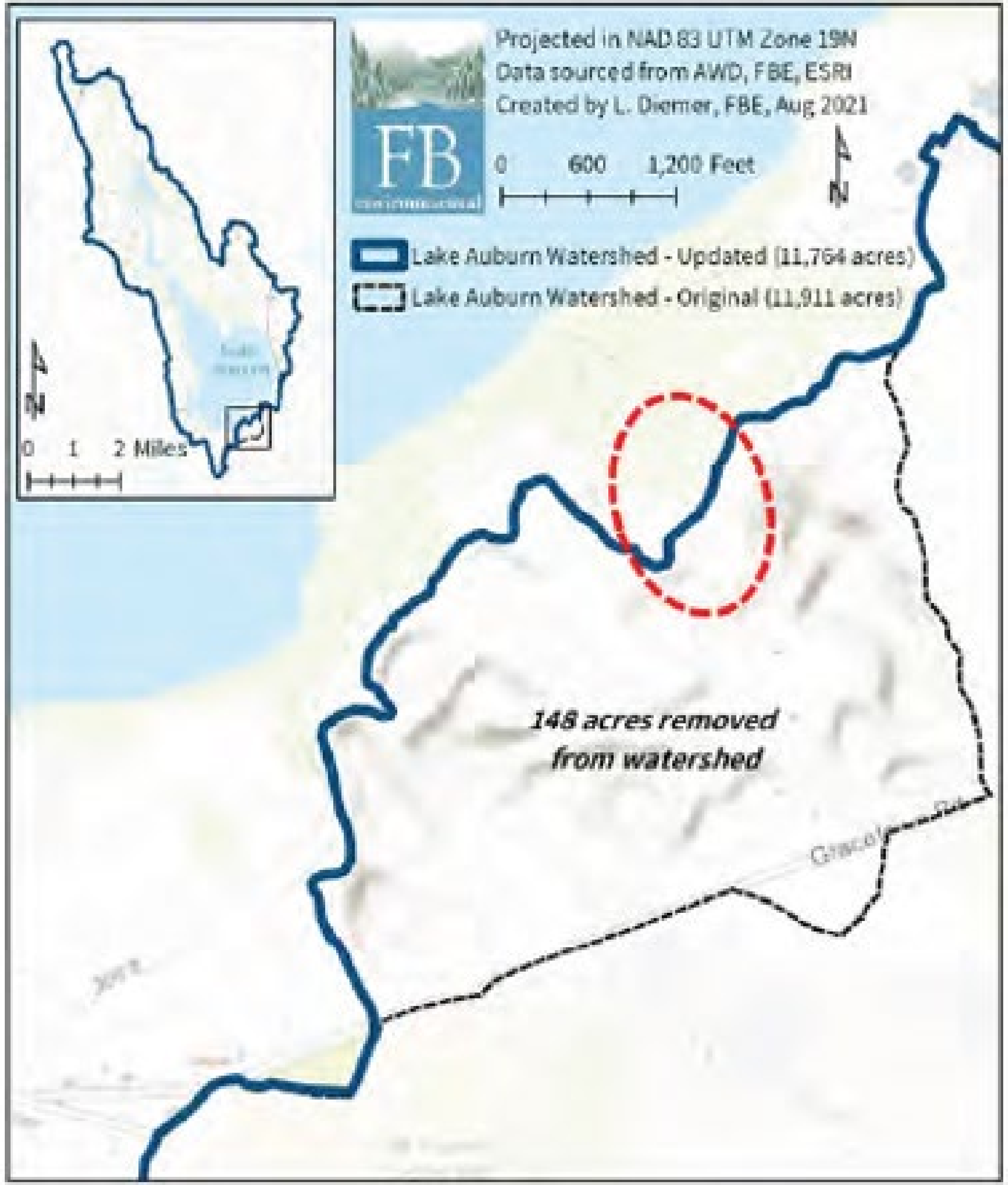


Figure 1 Previous (black dashed) and revised (blue) watershed delineation per FP Environmental (2021)

Figure 2 Google Earth aerial photo of study area

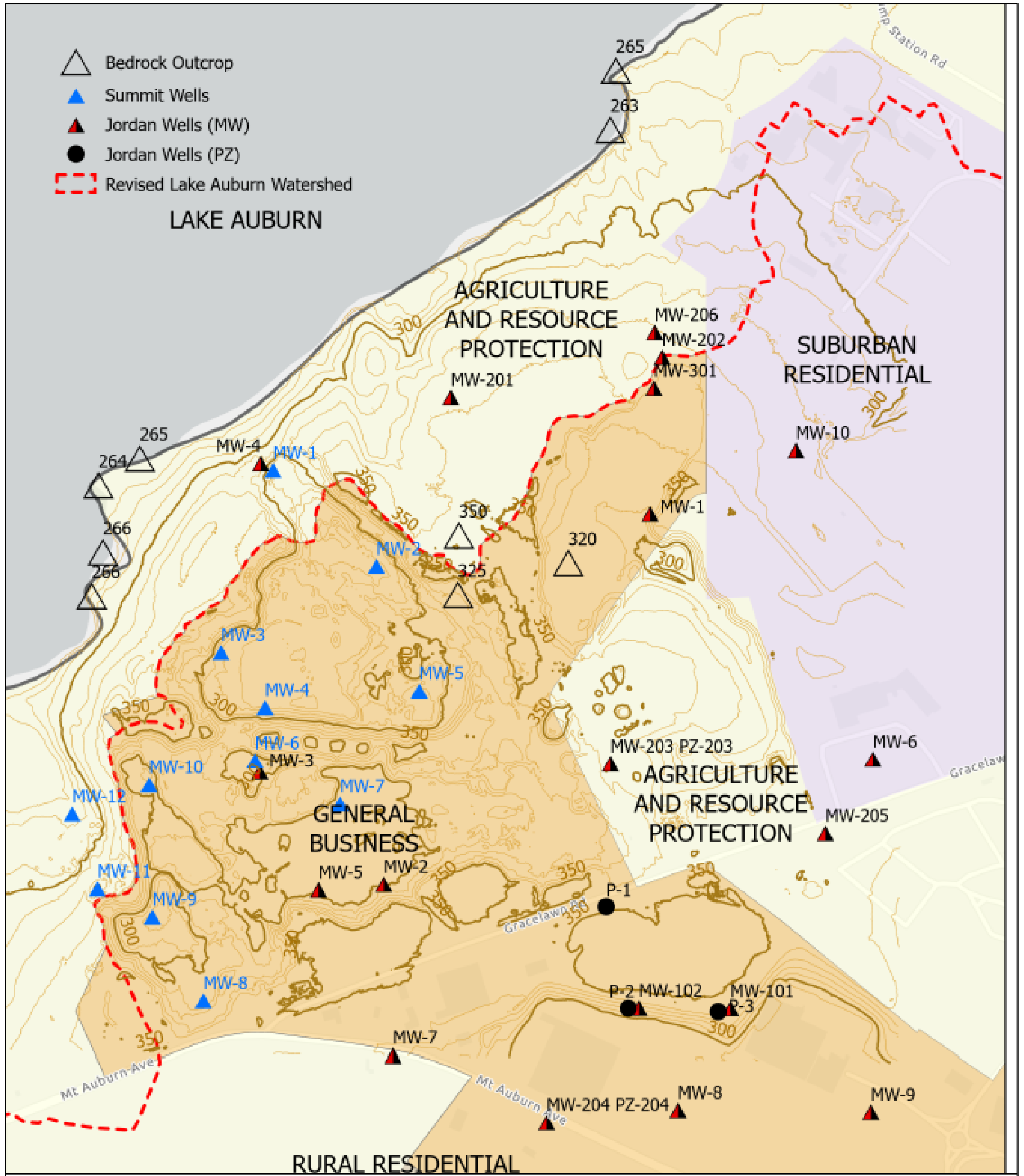


Figure 3 Land use zones

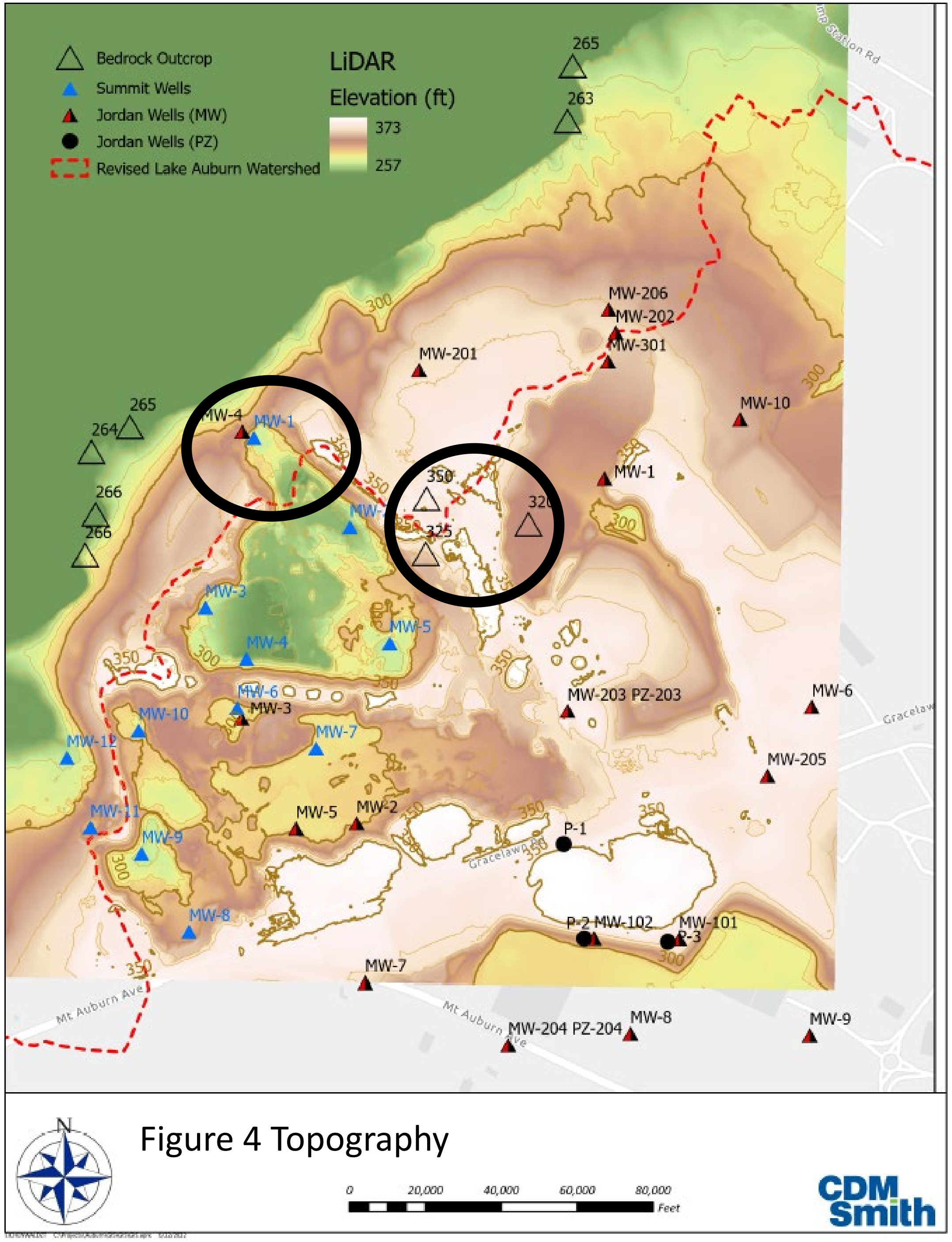


Figure 4 Topography

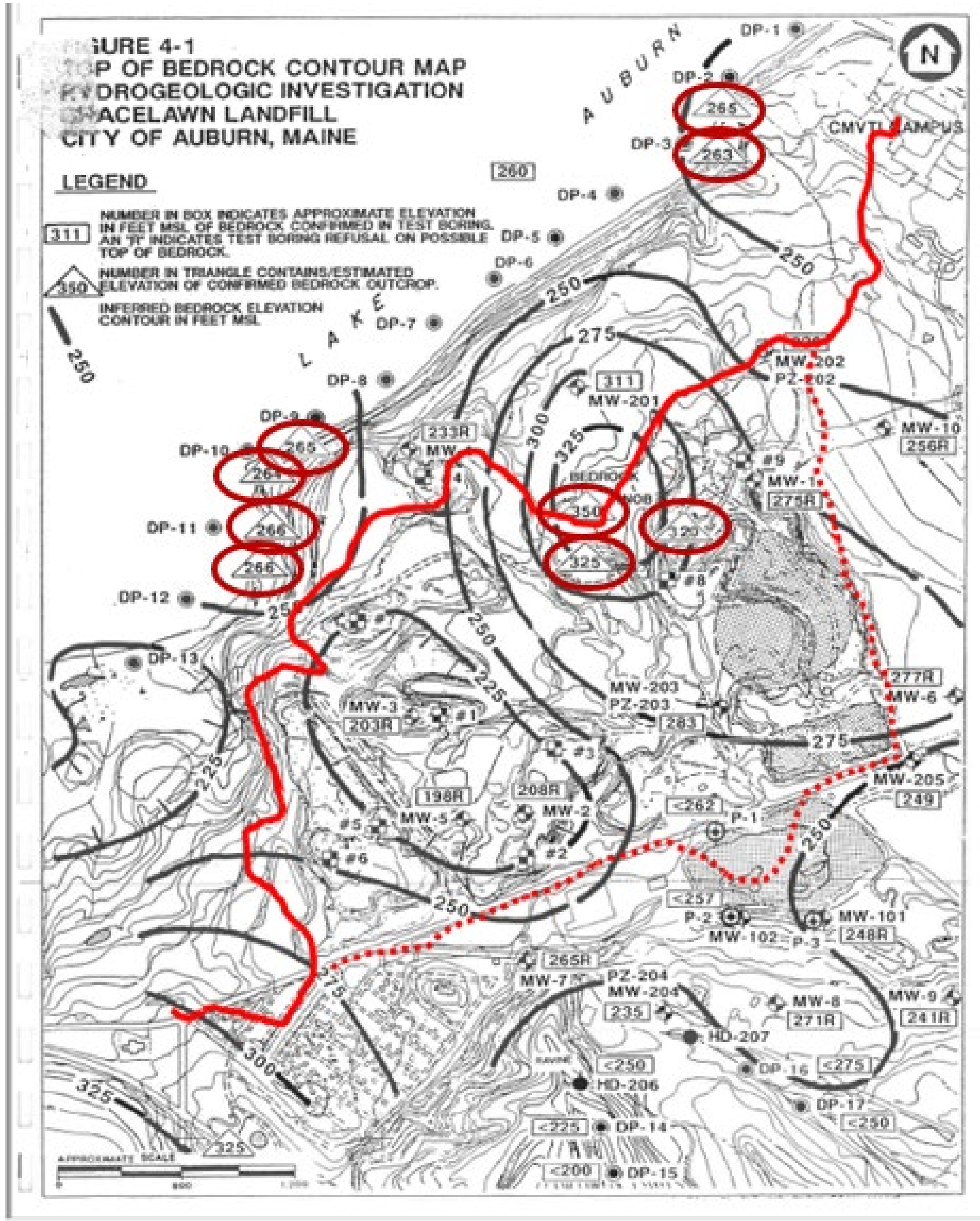


Figure 5 Bedrock surface contour map from E.C. Jordan (1990)

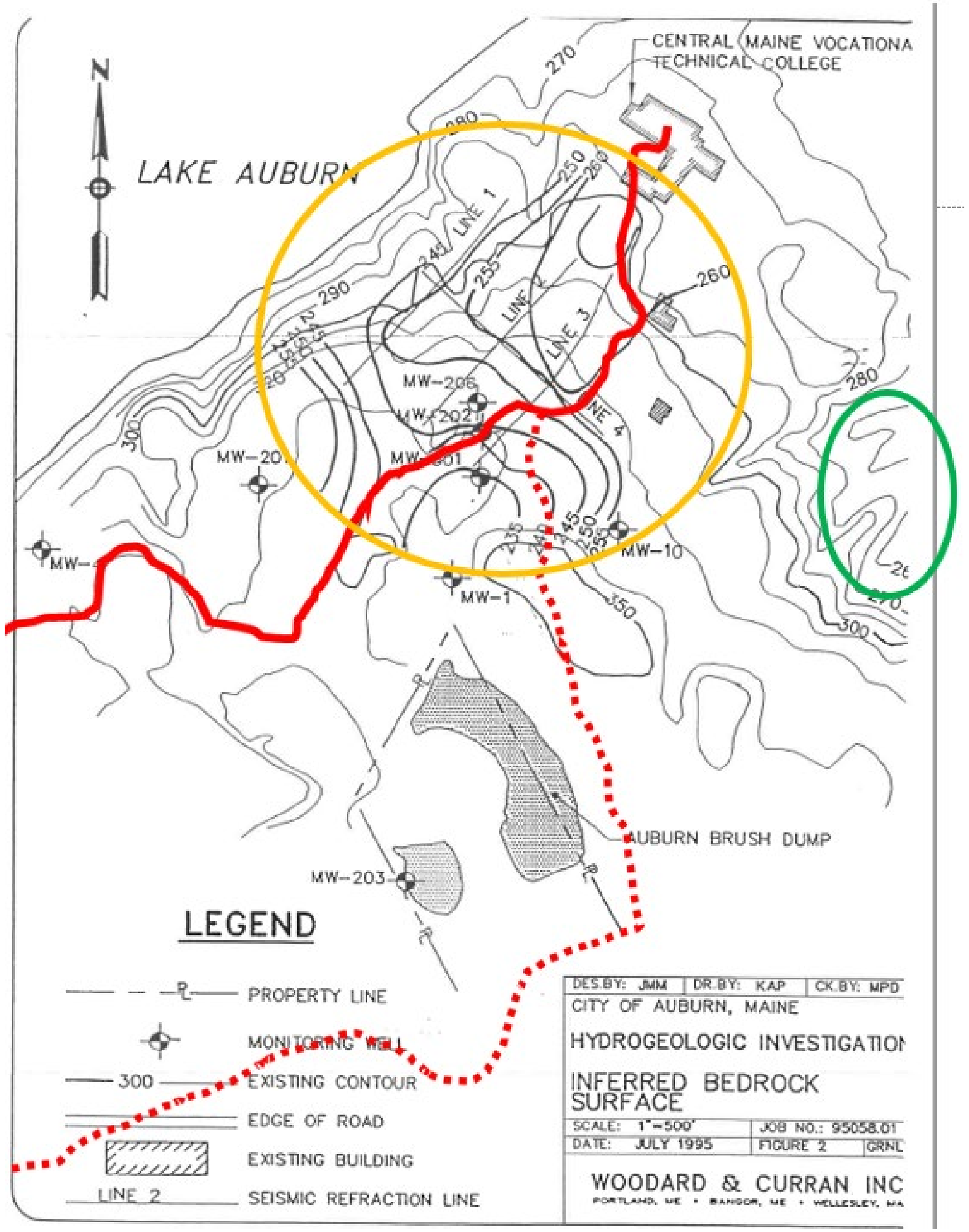


Figure 6 Bedrock surface contours from Woodward & Curran (1995)

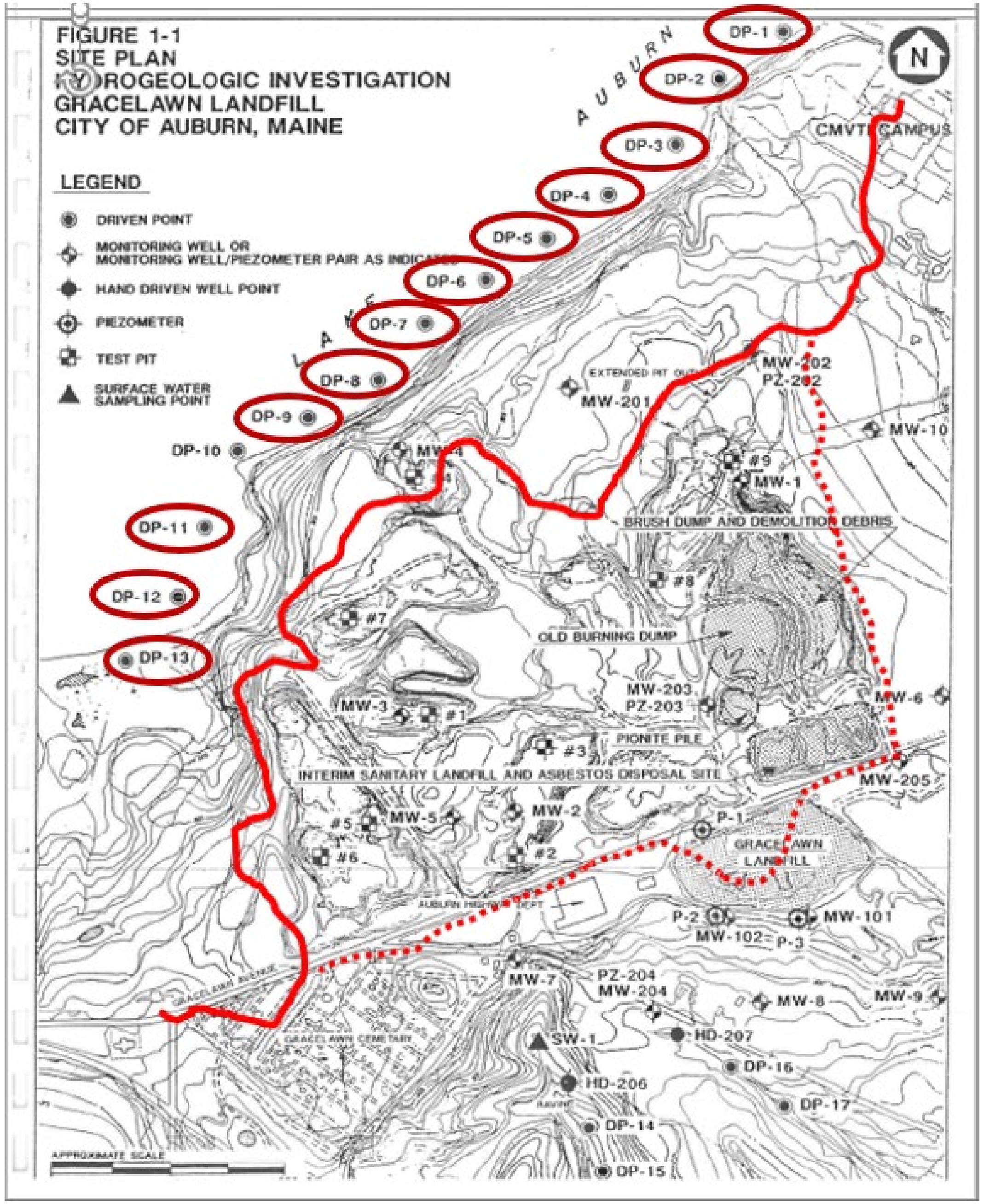


Figure 7 Subarea A: Lake Agawam sediment probes

Figure 8 Subarea B: Monitoring well MW-201 and bedrock "knob" outcrops

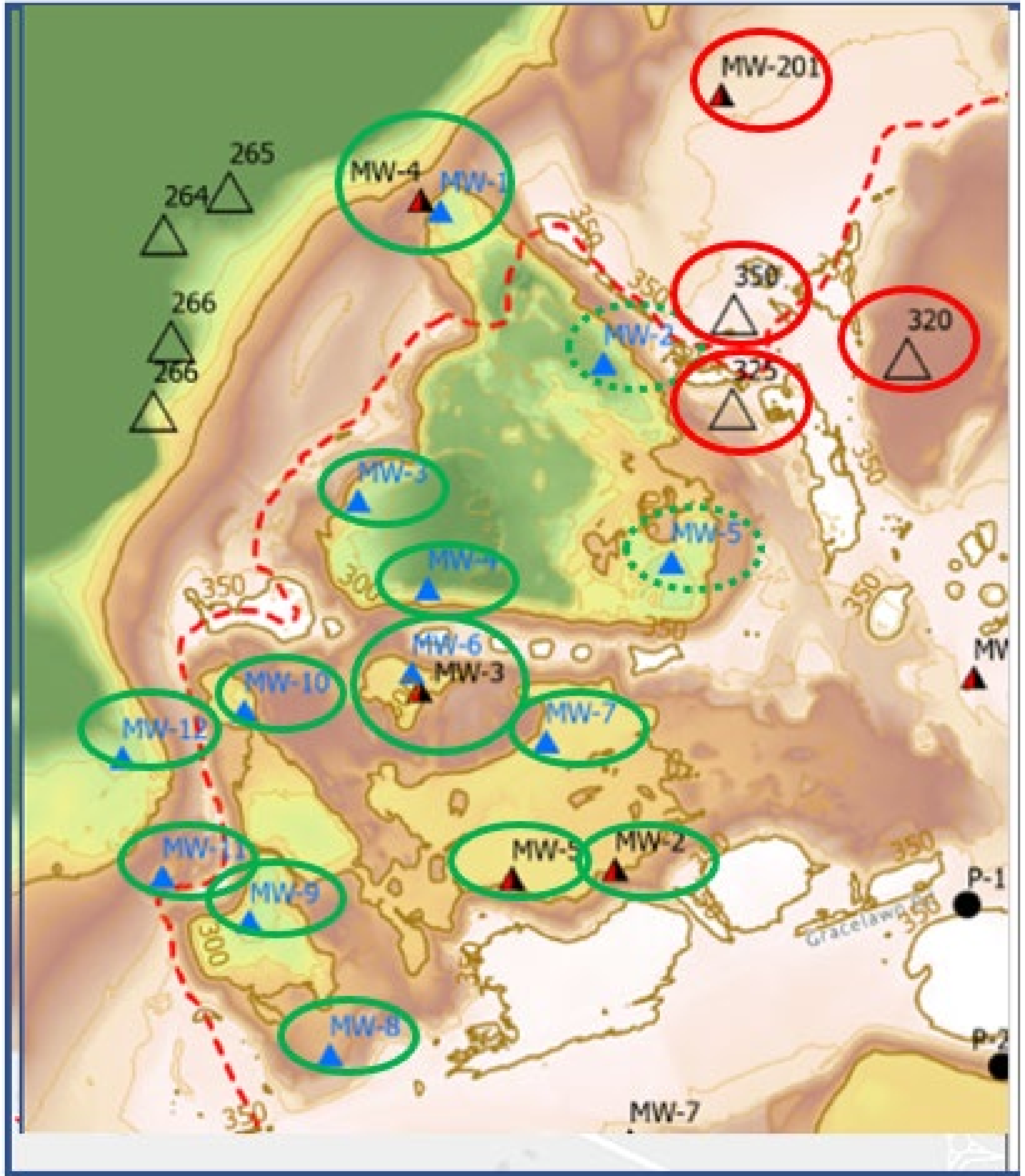
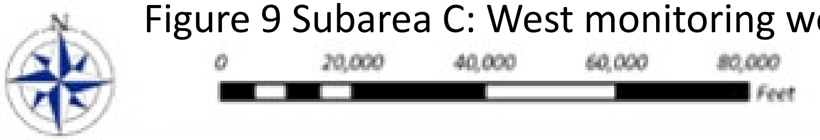


Figure 9 Subarea C: West monitoring wells



CDM Smith

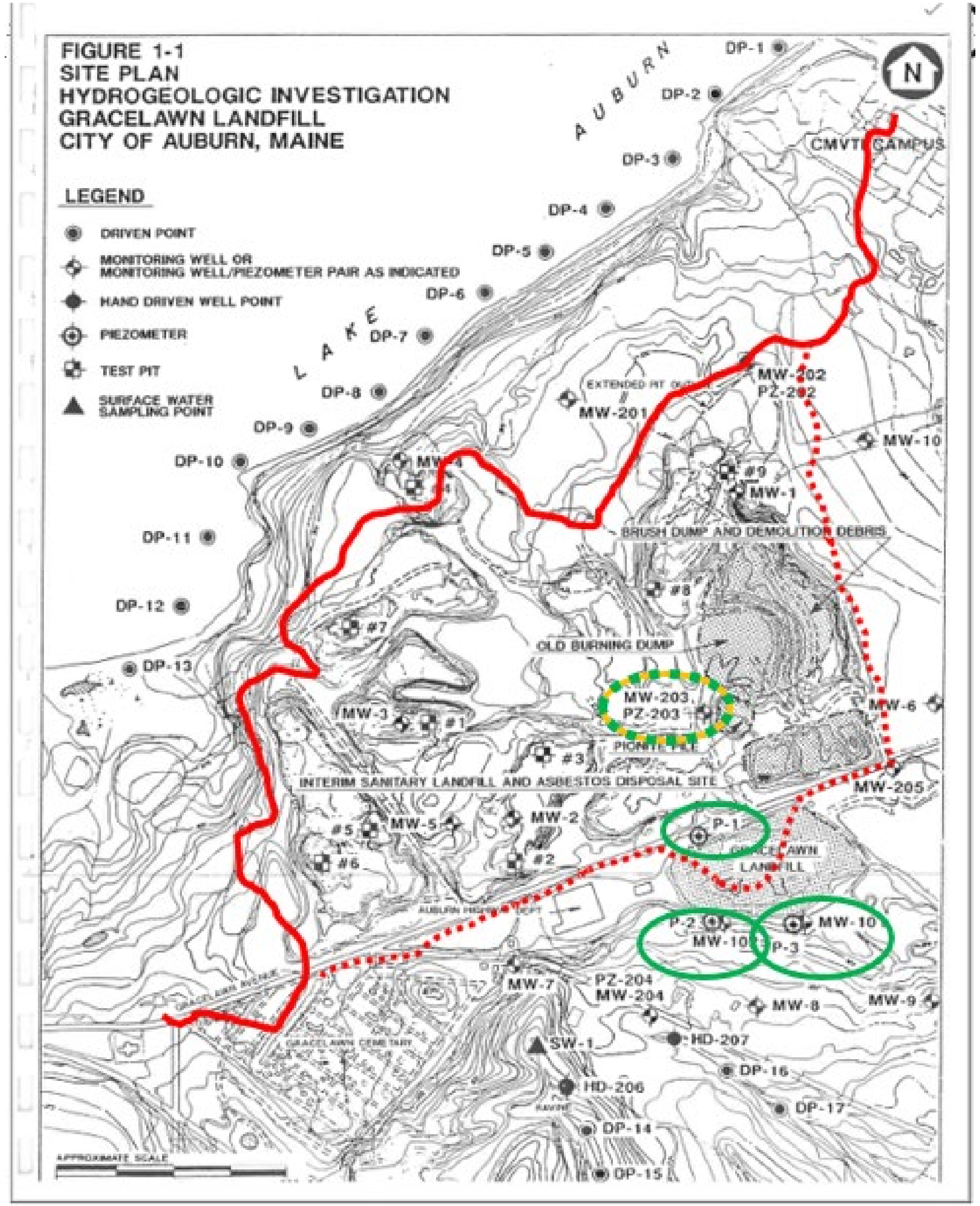


Figure 10 Subarea D: Gracelawn Landfill monitoring wells and MW/PZ-203

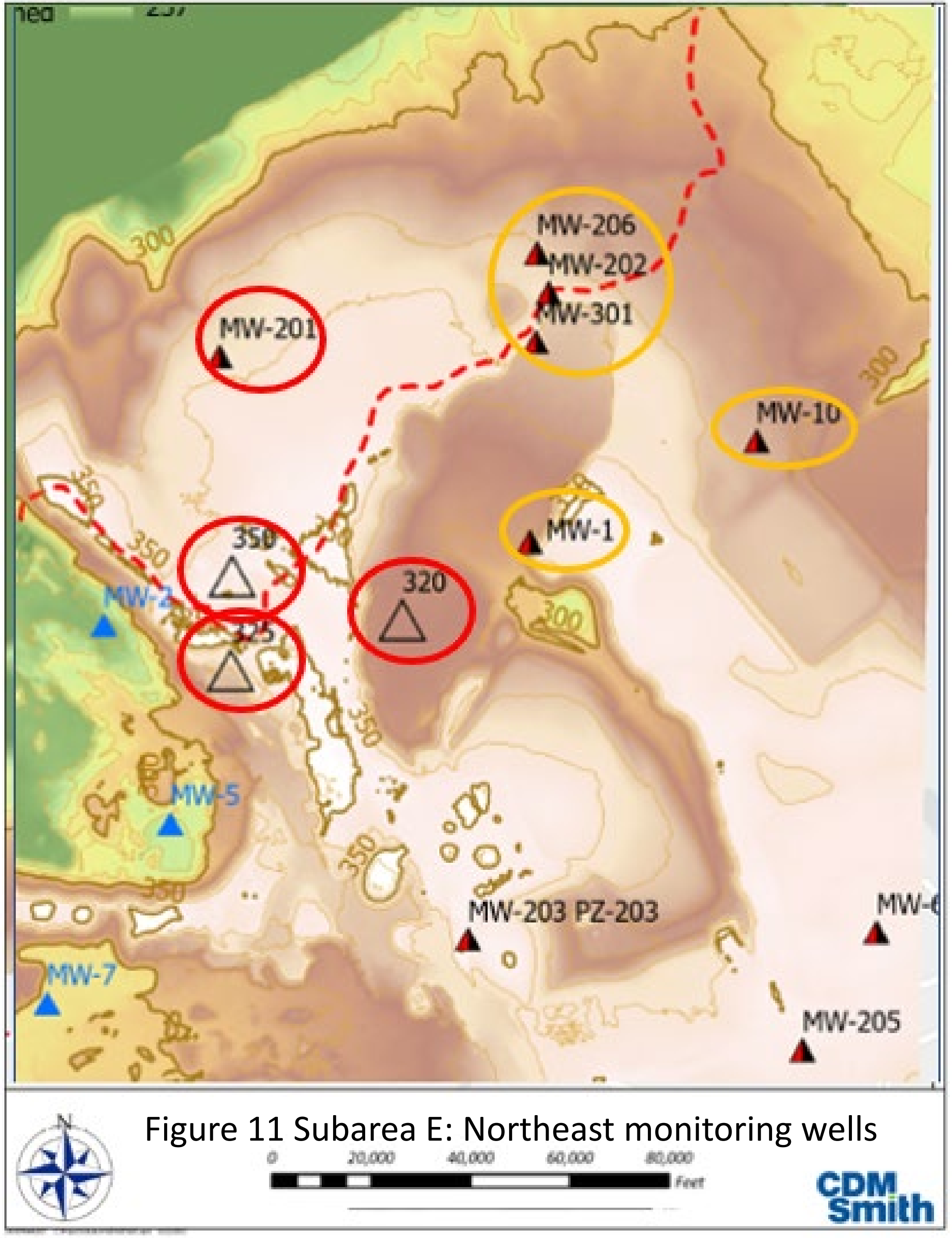


Figure 11 Subarea E: Northeast monitoring wells

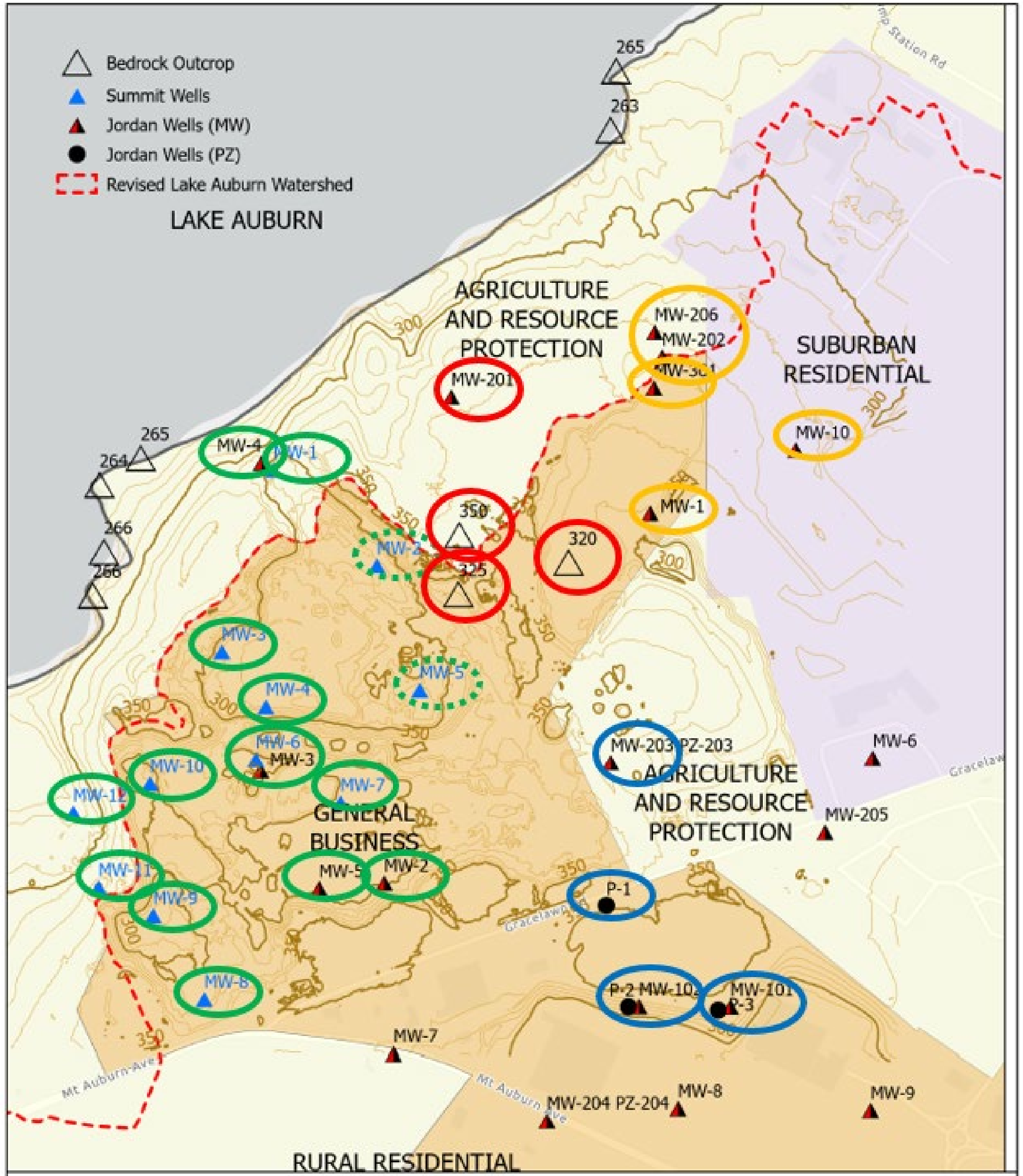


Figure 12 Study area monitoring wells and zoning

0 20,000 40,000 60,000 80,000 Feet

CDM Smith