SOURCE WATER ASSESSMENT PLAN
Town of Sharptown
Wicomico County, Maryland

ALWI Project No. WI7N063

1.0 INTRODUCTION

ALWI was retained by the Commissioners of Sharptown ("Sharptown" or the "Town") to develop a source water assessment and wellhead protection plan for the community groundwater system. The Town is served by four existing wells located at the Town Hall, approximately 0.4 mile north of the intersection of MD Routes 313 and 348, in Sharptown, northern Wicomico County, Maryland.

The work was funded by and performed following technical guidance and advice received from the Water Supply Program (WSP) of the Maryland Department of the Environment (MDE). Advanced Land and Water, Inc. (ALWI) Proposal No. WI7N063 was authorized by the Commissioners of Sharptown on May 8, 2000 and a subsequent contract of engagement was signed by a duly authorized County representative on August 11, 2000. This wellhead protection plan was then developed pursuant to ALWI's contract with Sharptown, MDE guidelines for Source Water Assessments and in cognizance of a Memorandum of Understanding (MOU) between MDE and the Town (Appendix A).

1.1 PURPOSE AND BACKGROUND

ALWI understands that one of the Town's principal motivations for the work was to support an application for state assistance to purchase a tract of farmland near the wellfield that was believed to be a potential source of nitrate-laden groundwater runoff. Sharptown also benefits from this source water assessment plan because the plan assesses the vulnerability of the aquifer (from both the aforementioned farm tract and other sources) and provides recommendations to mitigate the risk of public health degradation due to contamination of the groundwater supply.

As background, the Sharptown municipal water system serves approximately 700 residents and delivers an annual average of approximately 80,000 gallons per day. Sharptown has historically been served by four closely spaced production wells, two of which (Wells 1 and 6) are completed in the Nanticoke Aquifer, a sand layer within the Calvert Formation of the Atlantic Coastal Plain. Wells 4 and 5 draw water from the Columbia aquifer of probable Pleistocene age. No data exist from which to estimate their individual or combined sustainable yields in terms of management tools typically employed for such evaluations (e.g., peak demand, system redundancy in terms of the requirements of COMAR 26.03.02.03(2)B., etc.). Only three of the four wells remain in regular service; Well 1 is used as a backup supply in the case of emergencies. Well construction and testing records are included in Appendix B.

1.2 REGULATORY FRAMEWORK

In performing this work, ALWI followed MDE's source water assessment and wellhead protection guidelines, which stem from federal enabling statutes. The Safe Drinking Water Act (SDWA) of 1974 required the U.S. Environmental Protection Agency (EPA) to develop enforceable drinking water quality standards to protect the public health. In 1986, amendments made to the SDWA strengthened provisions for the protection of underground sources of drinking water. These amendments included provisions for establishing Wellhead Protection Programs by individual states under "umbrella" EPA oversight. The EPA approved MDE's Wellhead Protection Program in June 1991.

The 1996 Amendments to the SDWA required Maryland (and the other states) to develop a Source Water Assessment Program (SWAP). On an individual system basis, the SDWA provides guidance for an approvable source water assessment. Wellhead protection and source water assessments, therefore, are related in design and purpose. In accordance with MDE's 1999 SWAP guidelines and the MOU (Appendix A), a Wellhead Protection Plan consists of four interrelated components. These components are outlined below as follows:

- **WHPA Delineations** – A Wellhead Protection Area (WHPA) is defined as the surface and subsurface areas surrounding wells through which contaminants are reasonably likely to enter the subsurface and move toward and reach the well field. For confined, coastal plain aquifers, MDE recommends that WHPA delineations be based on a volumetric calculation for determining travel-time-dependent capture zones. For unconfined aquifers, MDE suggests that the delineations be based on the EPA WHPA Code groundwater model.

- **Contaminant Hazard Identifications** –Existing and potential contaminant sources within the WHPA present variable risk to the water supply depending on site conditions, engineering controls and other factors. Such sources are identified by field reconnaissance and publicly available, spatially-indexed databases and maps. The 1999 SWAP guidance document lists the following contaminants as potential concerns in community groundwater supplies: organics (volatile and synthetic compounds); heavy metals; nitrate/nitrite; fluoride; cyanide; asbestos; radionuclides; bacteria (total and fecal coliform); protozoa and viruses.

- **Susceptibility Analysis –** Not all contaminant hazards pose equivalent risk of water quality impact. As stated above, site conditions and engineering controls are important considerations in assessing the relative vulnerability of the water supply. Sanitary surveys (field reconnaissance data), well completion reports and existing water quality data in the form of laboratory analyses are primary tools for assessing susceptibility of a supply to existing and historical contamination sources. The 1999 SWAP guidance document identifies many sub-elements of susceptibility analyses, including (1) presence of contaminant sources within the WHPA; (2) natural source removal and reduction capabilities of the aquifer; (3) potential chemical changes triggered by the presence of contaminants; (4) physical integrity of the well; (5) toxicity, solubility, eutrophication and degradation potentials for the contaminant and (6) environmental fate and transport issues (e.g., dispersion, dissolution, etc.).

- **WHPA Management Tools** - Management of the WHPA is another key component of the guidelines and includes a variety of measures focused on the proactive mitigation of future contaminant hazards. Associated contingency plans can include water supply replacement, upgraded treatment and/or a diversity of public education and outreach programs. ALWI came to recognize and recommend the benefit of a multi-zone WHPA, wherein varying protective measures are recommended for implementation depending on the degree and immediacy of hazard potentially posed to the municipal supply wells.

2.0 HYDROGEOLOGIC FRAMEWORK

Within ALWI's experience, a scientifically sound and well-reasoned WHPA delineation is key to effective wellhead protection. For this reason, ALWI began its technical work by evaluating the site-specific hydrogeologic framework underlying and surrounding the municipal production wells. ALWI used published information from the United States Geological Survey, the Maryland Geological Survey (MGS) and the Cecil County Soil Conservation Service (an agency of the United States Department of Agriculture) to identify and describe the characteristics of the local hydrogeologic setting. As aforementioned, ALWI also obtained records from MDE and from the Town to help confirm specific information regarding the wells.

2.1 GEOLOGY/HYDROGEOLOGY

Sharptown is located within the Atlantic Coastal Plain physiographic province, which is comprised of sub-horizontal sand, silt and clay layers that gradually thicken and dip in a southeasterly direction (Chapelle, 1985). At the project site, the sediments of the Atlantic Coastal Plain are approximately 1,400 feet thick and unconformably overlie the schists and gneisses of the Piedmont physiographic province (Cushing and others, 1973).

Two of the existing municipal supply wells are completed in the Calvert Formation, a sub-unit of the Chesapeake Group of middle Miocene age. The Calvert Formation is generally a gray silt aquiclude but contains two relatively thin partially cemented fine to very fine sand layer. One of these layers present in western Wicomico County is termed the Nanticoke aquifer, with a reported thickness of 39 feet at Sharptown U.S. Geological Survey Observation Well No. Wi-Ad-1 as reported in Rasmussen and Slaughter (1955). Other communities using the Nanticoke aquifer for public supply historically included Vienna and Crisfield.

The other two wells are completed shallowly in Pleistocene or Pliocene-aged sands of per-glacial origin. These sands occasionally contain cobbles, gravels, and less commonly, silts and clays. Many prolific wells have been developed in these sands, sometimes called the Columbia aquifer, across the central and lower portions of the Delmarva Peninsula.

At the outset of this investigation, ALWI researched the potentiometric heads present in the Sharptown area and determined that the two deep wells are under confined conditions whereas the two shallow wells are under unconfined conditions. Insofar that each aquifer's status relative to confining[1] conditions is key to selection of a WHPA delineation methodology, ALWI confirmed MDE's acceptance of this determination in writing before work began (Appendix A).

2.2 AQUIFER RECHARGE

Precipitation infiltrating through the soil above the subcrop of the formation and/or via slow vertical leakage from overlying and underlying formations are the primary sources of aquifer recharge to the deep production wells. The shallow wells likely are recharged by direct precipitation falling on land surface within their capture zones and in topographically up-gradient areas.

2.3 NATURAL WATER QUALITY

Groundwater in both the Nanticoke and Columbia aquifers is generally considered suitable for consumption. Nanticoke aquifer water is typically high in iron but high in sodium bicarbonate, is generally regarded as less palatable, and is harsher on equipment. Columbia aquifer water has more favorable secondary (aesthetic) characteristics but is high in nitrate from anthropogenic activity. Violations of the Maximum Contaminant Level (MCL) for nitrate have been reported from the Columbia aquifer wells at Sharptown, but finished water remains within potability standards due to blending. Available laboratory analyses of samples from the production wells in Sharptown typify local water quality conditions and suggest that the water from these wells is adequate for potable uses (Appendix B).

3.0 WHPA DELINEATIONS

In confined coastal plain aquifers, MDE's Source Water Assessment Guidance Document (1999) recommends that WHPA delineations be based on a volumetric equation. In unconfined aquifers, MDE suggests delineating WHPAs based on EPA's WHPA Code groundwater model. The specific methods ALWI used to generate one-year and ten-year time-of-travel based capture zones are presented and discussed in Appendix C.

Published guidance from both MDE and EPA publications extols the primary virtue of the zonal designations within WHPAs being a gradational increase in the degree of land use restriction as commensurate with increased risk of water quality degradation should a release occur. This division allows for varied protective measures for the water supply depending on the likelihood and immediacy of the hazard posed to the wells.

Sharptown's delineated WHPA zones are somewhat complex owing to the differing methods used depending on the aquifer conditions present (confined vs. unconfined). ALWI delineated one-year and ten-year time-of-travel based capture zones for both the shallow

[1] COMAR 26.04.02.01(43) defines "unconfined aquifer" as "an aquifer not bounded above by a bed of distinctly lower permeability than that of the aquifer itself and containing groundwater under pressure approximately equal to the atmosphere." Conversely, COMAR 26.04.02.01(8) defines a "confined aquifer" as an "aquifer bounded above and below by beds of distinctly lower permeability than that of the aquifer itself and which contains groundwater under pressure greater than that of the atmosphere". COMAR further states that the terms "unconfined aquifer" and "water table aquifer" are synonymous and that the terms "confined aquifer" and "artesian aquifer" are also synonymous.

(Pliocene/Pleistocene) and deep (Nanticoke) aquifers, separately using MDE-approved techniques (Figure C-1). In delineating the final WHPA management zones, ALWI considered the overall contaminant threat to the shallow wells to be more significant considering their unconfined status and the shorter vertical travel times for a contaminant of anthropogenic origin to reach the wells. ALWI also considered a need for simplified, easily managed zones (recommended management strategies for each zone are presented in Section 6.0.)

3.1 ZONAL DESIGNATIONS

ALWI numbered each zone, from inner to outer. Lower numbers connote greater risks of adverse water supply impacts due to contamination occurrences.

1. **Zone 1** - Shown in red on Figure 1, Zone 1 was delineated using the EPA WHPA code as a one-year time-of-travel capture zone around shallow well Nos. 4 and 5 (Appendix C). ALWI then manually expanded this zone slightly on its northwest side so as to encompass the wellhead locations for deep well Nos. 1 and 6 within the Zone 1 delineated area. This is in recognition that water supply contamination to the deeper aquifer can quickly occur if the wellbore serves as a conduit for the downward migration of contaminants spilled at the wellheads. For conservatism, ALWI also manually adjusted Zone 1 in a northwest direction so as to include all areas within 100 feet of Well Nos. 4 and 5 regardless of land surface topography. ALWI notes that, by happenstance, Zone 1 also encompasses most of the composite one-year capture zone area derived for the Nanticoke aquifer using the volumetric flow equation (a.k.a. "Florida Method") and equation no. 4-6 of Boulding (1994).

2. **Zone 2A -** Shown in orange in Figure 1, Zone 2A is the ten-year time-of-travel based capture zone within the Columbia aquifer, from which water could flow into the wells during the course of a decade. Initially Zone 2A extended further toward the southeast but ALWI judged it appropriate to truncate based on a topographic criterion (pink dashed line on Figure C-1). Even so, the distal portion of Zone 2A crosses the Mason-Dixon line into an unpopulated area of southwestern Delaware.

3. **Zone 2B** – Shown in green in Figure 1, Zone 2B is the remainder of the composite one-year capture zone area derived for the Nanticoke aquifer using the volumetric flow equation (a.k.a. "Florida Method") and equation no. 4-6 of Boulding (1994).

4. **Zone 3** - Shown in blue in Figure 1, Zone 3 was derived in the manner of Zone 2B except that a ten-year time-of-travel based capture zone was used.

The zonal designations were developed based on the MDE accepted methods for the aquifers underlying Sharptown with consideration of ambient flow. Discussion of the technical facets of these delineations is located in Appendix C. Figure 1 depicts the zonal delineation of the WHPA for Sharptown.

3.2 UNCERTAINTY ANALYSIS

ALWI's WHPA delineations are predicated on, among other factors, regional head distributions measured in the 1990s and by ALWI during the course of this study as follows. Key parameters and associated uncertainties are listed as follows, in approximate decreasing order of overall significance:

1. **Relative Usage of the Aquifers** – ALWI assumed that the proportionality of shallow vs. deep aquifer use would remain as shown in Figure C-2. Differing pumpage distributions could cause expansion or contraction of the WHPAs.

2. **Direction of Ambient Flow in Columbia Aquifer** – ALWI assumed that the Columbia aquifer discharges to the Nanticoke River with flow lines sub-orthogonal to the main stem of the River. Horizontal variance and imprecision in this flow direction was considered to be 30^o based on shallow monitoring well networks maintained near streams in other locations[2]. Accordingly, the north-to-south width of Zone 2A is a function of this directional uncertainty and its possible seasonal fluctuation. Better data could result in the widening, narrowing and/or rotational movement of Zone 2A by (perhaps) as much as several degrees.

3. **Hydrologic Gradient in Columbia Aquifer** - ALWI used static water levels in an existing shallow irrigation well and (as reported) in Well Nos. 4 and 5 to establish the local hydrologic gradient, thus relying on data collected using different means, by different individuals and in different years. The resultant gradient (0.0015) seemed plausible considering the local topography and ALWI's overall experience. Gradient dictates the overall length of the delineated area in a direction parallel to ambient flow lines. Considering the topographic truncation of the resultant WHPA, a substantial steepening of the gradient would be necessary to trigger a change in the delineated WHPA. ALWI judges this unlikely.

Other parameters also incorporate assumptions but the associated potential for error seems less significant (i.e., setting aquifer thickness equal to screen height seems plausible). Despite these limitations, in meetings held October 31, and November 16, 2000, MDE reviewed and approved delineations herein. ALWI recommends that municipal interests remember to consider the potential impact on these delineations when changing the governing philosophy behind the distribution of pumpage by aquifer or when a new well becomes available for water level observation. ALWI recommends that the hydrogeologic basis for the WHPA delineations be reviewed on a triennial basis so that changes in underlying assumptions may be considered and factored into a revised delineation.

4.0 CONTAMINANT THREATS AND SUSCEPTIBILITY ASSESSMENT

ALWI performed a regulatory database review, field reconnaissance and limited interviews and file reviews to identify potential sources of contamination within the WHPAs. ALWI considered both point and non-point sources of contamination.

[2] Three shallow monitoring wells located in the floodplain of Herring Run were gauged and monitored quarterly for several years. During dry periods, groundwater flow was perpendicular to Herring Run. However, during wet periods groundwater flow rotated down gradient approximately 30^o.

4.1 POTENTIAL CONTAMINANT SOURCES TO THE COLUMBIA AQUIFER

ALWI began to identify point-source contamination hazards to the Columbia aquifer by acquiring site-specific listings of Federal and State environmental databases from Environmental Data Resources, Inc. [EDR] (Appendix D) encompassing the entire WHPA. ALWI reviewed this listing for facilities where government agencies track the use, handling, storage, disposal and treatment of hazardous wastes and petroleum products[3].

Only one site (a registered underground storage tank (UST) containing heating oil located Mount Vernon United Methodist Church) was listed as being located within the WHPA. Sharptown municipal representatives later confirmed that EDR had mismapped this church and that indeed, it's true location is outside the WHPAs. EDR also provided an unsorted list of local contaminated properties within that could not be assigned specific geographic coordinates ("orphan sites"). The WHPA does not seem to contain listed orphan sites.

ALWI supplemented the EDR database review with a visual reconnaissance within WHPA Zone Nos. 1 and 2A on September 11, 2000. During this reconnaissance, local land use conditions were observed with emphasis on the potential use, storage and disposal practices of hazardous materials and petroleum products in such a location where the entrainment of contaminants could occur and then could enter the subsurface at the wellheads. Such conditions may have included visual evidence of present or former spills, stained or discolored ground surfaces, stressed vegetation, unusual odors or visible underground storage tank facilities. Adjacent and nearby properties were visually scanned to the degree practicable from public rights-of-way[4].

ALWI's field reconnaissance indicated that all four municipal production wells appear to possess physical integrity, though no subsurface or invasive work of a confirmatory nature was performed. No confirmed sources of existing, direct contamination to the wells or aquifer within WHPAs was confirmed by the results of the site reconnaissance. Other pertinent observations were as follows, with the corresponding letters cross-referenced to the map (Figure 1):

A. **Agricultural Land Use in Zone No. 1** - ALWI's observations did not confirm municipal officials' reports of large stockpiles of nitrate-containing fertilizer material on the farm tract immediately southeast of the wellfield. ALWI understands that MDE and MD Rural Water Association personnel confirmed these reports by direct visual observation. ALWI observed visual evidence of truck-farming fruits and vegetables being grown in this location but absent visible fertilizing materials (broccoli, cantaloupe, watermelon, etc.).

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[3] ALWI notes that the inclusion of registered UST sites and hazardous waste generation sites within the EDR database is an incidence of environmental compliance. Inclusion does not necessarily imply the existence of a reported environmental release.

[4] Though ALWI did not identify specific contamination threats warranting further investigation or corrective action, (1) contaminant hazards may exist that remain undetected because of limitations in the methods employed (concealed visual evidence, etc.) and/or (2) new contamination hazards may develop in the future. For these reasons, the measures employed herein for identifying contaminant hazards should be revisited periodically for the Plan to remain current.

B. **Shallow Domestic Irrigation Wells** - ALWI observed several 1-inch to 2-inch diameter PVC wellheads in residential portions of Zone 1. Municipal representatives explained that these are likely shallow irrigation wells, presently permissible by municipal ordinance. It was further explained that these wells are typically hand-driven or augured to the shallowest producing sand at a nominal 20-foot depth. ALWI performed a more detailed surface reconnaissance of one presumably representative well and observed an absence or near-absence of casing protection and grout (e.g., the PVC well casing spun freely with modest hand-torque applied by municipal representatives).

C. **Municipal Sewage Sludge Application Area** - ALWI observed a small area of Zone No. 2A approved for use for the disposal of municipal sewage sludge. This area displayed verdant vegetation but otherwise did not possess visual indication of contaminant releases or environmental stress. ALWI understands that municipal sludge application in this area is permitted by MDE but performed no confirmatory file reviews or other assessments of the composition, transport or specific fate of the sludge and compounds therein.

D. **Chicken House** – ALWI observed several chicken houses bordering the northern boundary of Zone No. 2A. A portion of one chicken house crosses into Zone 2A. The chicken house facilities appeared not to be in use at the time of ALWI's reconnaissance. ALWI observed no visual evidence of contaminant releases or other environmental stress on the land surrounding the chicken houses. No other information was available.

E. **Agricultural Land Use in Zone No. 2A** – Widespread portions of Zone 2A are cultivated field, particularly east of the Sharptown bypass. Non-point source contamination by nitrates, phosphorous and other agricultural byproducts is envisionable. However, ALWI's observations did not suggest over-application of fertilizers or pesticides. No other information was available.

F. **Farm Dump** - ALWI observed an informal refuse disposal area near the far southeastern boundary of Zone 2A. Most of the disposed materials consisted of building debris, junked vehicle parts and components of old machinery. ALWI also observed 55-gallon drums, 275-gallon tanks and oil-stained soil in this location. No stressed vegetation was observed and no other information was available.

Available analytical laboratory reports and consumer confidence reports (Appendix B) indicate that nitrate concentrations in the Columbia aquifer wells approaches or exceeds the MCL of 10 mg/l. Sharptown's shallow municipal supplies do not presently appear susceptible to other contaminants, insofar as no other compounds or parameters have been detected in concentrations exceeding 50% of the respective MCL.

4.2 POTENTIAL CONTAMINANT SOURCES TO THE DEEP AQUIFER

In practicality, for the confined aquifers of the Atlantic Coastal Plain including the Nanticoke aquifer at Sharptown, non-point sources (e.g., agricultural land use practices; highway deicing; railroads, etc.) appear to pose little risk because of the presence of confining units that serve to isolate the screened aquifer from the hazard of surficial spills. Only where those confining units are perforated by wells does such a hazard potentially exist. Accordingly, absent such wells and their resultant short-circuit contamination pathways, ALWI judges that the hazard from other surficial leaks or spills is *de minimus* in Zones 2B and 3 and did not further evaluate such hazards herein.

Accordingly, ALWI judged point sources to pose a potential risk of water supply contamination only if the establishments at which the hazards are located possess, or are located in proximity to, the production wells or other wells screened in the same aquifer as that used for municipal supply (in the case of Sharptown, the Nanticoke Aquifer). ALWI further hypothesized that the most likely risk of contamination to the supply wells would originate from other wells improperly constructed and/or imprudently used for waste disposal. Finally, by extension, ALWI surmised that the risk of aquifer contamination from the accidental or wrongful discharge of contaminants through a well would be greatest at commercial and industrial facilities where wells exist that are screened in the same aquifer as the community supply in need of protection. Following this rationale, ALWI designed its work to identify such potential hazards.

ALWI did not observe visual evidence for deep wells in Zone Nos. 1, 2B or 3, which in combination comprise and slightly exceed the aggregate ten-year capture zone in the Nanticoke aquifer. Municipal officials indicated no awareness of other Nanticoke aquifer wells within this area. ALWI supplemented this evaluation by accessing the database of holders of Water Appropriation Permits, maintained by the MDE Water Rights Division. ALWI requested a database report of commercial and industrial permitees authorized to make withdrawals from the Nanticoke aquifer (a.k.a. Calvert Formation and Chesapeake Group in Water Rights Division files) in the Sharptown area.

The MDE Water Rights Division sorts their database of permitees by "use code". ALWI requested a search for use code 103 (commercial) and all codes in the 300 series (industrial). Similar sorting capabilities are available by aquifer code. ALWI furnished MDE geographic constraints based on the Maryland Grid Coordinate system such that the resultant database report would include the WHPAs plus a suitable surrounding area to account for possible errors in database compilation (e.g., incorrectly interpolated grid coordinates). No such wells were identified in the Sharptown area and the laboratory data did not indicate that the deep wells at Sharptown are otherwise susceptible to groundwater contamination.

5.0 WHPA MANAGEMENT AND PLAN IMPLEMENTATION MEASURES

For any wellhead protection plan to be beneficial to its users, it has to be well reasoned, technically defensible and easy to implement. ALWI advocates a combination of measures to identify and mitigate the threat of future contamination to the Sharptown water supply. The multi-zone WHPA suggests differing degrees of hazard reduction by recognizing differing degrees of risk to the water supply.

5.1 HAZARD REDUCTION STRATEGIES

When compared to other municipal water sources in Maryland, the deep Sharptown wells are less at risk than most considering the confined hydrogeologic setting and the presence of few incompatible land uses in the WHPA. The shallow wells have demonstrated a susceptibility to nitrate contamination but not to other sources or compounds. Nevertheless, the following measures could help further reduce the risk and extent of potential future contamination.

ALWI generally recommends decreasing restrictions in land uses with increasing distance from the wellheads, such that Zone 1 is the most restrictive. Generally, in Zone 1 no new contaminant hazards would be allowable and facilities with existing hazards should be required to mitigate the hazard by using the most protective technology possible when upgrading or replacing systems. In Zones 2A and 2B[5], new hazards could be allowable if appropriately protective technology was incorporated in the design of the facility. Zone 3 generally is an area earmarked for voluntary hazard reduction, public awareness and community outreach.

As customized for Sharptown, specific recommendations are provided below. The order of these recommendations reflects ALWI's judgment of their relative importance:

1. **Nitrate Source Reduction on Adjoining Property** – ALWI recommends cessation of the practice of outdoor fertilizer storage on the farm track adjacent to the municipal wellfield. As a lesser recommendation, ALWI recommends discontinuance of agricultural fertilization of this tract. Insofar as ALWI understands that the Town has attempted to solicit cooperation on these matters from the property owner without past success, ALWI recommends that the Town proceed with its plan to acquire the tract in question. Park land and open space are examples of compatible land uses for this tract.

2. **No New Wells on Private Property in Town** – Sharptown Municipal Ordinance No. 44, enacted in 1990, prohibits wells within Town for purposes other than lawn irrigation and disallows cross-connections to the municipal system. ALWI recommends that this ordinance be further modified so as to prohibit (1) new shallow wells in the Zone 1 area and (2) new deep wells (greater than 30 feet) within Zones 1, 2B and 3. Ideally, existing deep wells in these three zones should be abandoned and sealed as well.

3. **Private Well Inspection and Condemnation** – Municipal Ordinance No. 44 prohibits cross-connections. Under the associated right of entry, the Town should regularly and diligently inspect the premises of well owners for evidence of cross-connections and other practices and facilities suggestive of a direct and/or immediate groundwater contamination hazard (i.e., leaking tank; stressed vegetation, etc.). Consideration should be given to amending Ordinance No. 44 to give the Town the right to condemn, abandon and seal wells it judges to pose such a direct and/or immediate contamination risk, ideally as well as to take other investigative and remedial actions it judges appropriate.

4. **Voluntary Abandonment of and/or Hazard Management Near Existing Private Wells** - ALWI recommends a community outreach program to encourage owners of existing wells in Zone 1 to abandon and seal those wells, pro-actively. Regressive water use pricing (e.g., a discount in the per gallon cost over 50,000 gallons per quarter) that would make lawn

[5] ALWI judges that a potential risk of anthropogenic contamination in Zone Nos. 2A and 3 would arise only from the direct release of contaminants into the portion of the Nanticoke Aquifer underlying the WHPA. Existing wells provide the most likely conduit for such a release. If such wells exist at commercial and industrial facilities where hazardous materials and petroleum products are used and/or stored, then both a potential source and pathway exists.

irrigation affordable could be considered as a means to encourage abandonment of the shallow wells. The Town also should develop a community awareness program for Zone 1 residents detailing the importance of (1) prudent use and appropriate disposal of household wastes; (2) appropriate nitrate and phosphorous management techniques; and (3) the consequences of accidental and/or inappropriate waste disposal and/or groundwater contamination. ALWI also recommends the establishment of voluntary household hazardous waste collection days.

5. **Wellhead Maintenance on Town Property** – One of the greatest threats to water supply contamination occurs at the wellhead. The best protection against this risk is achieved through wellheads that are maintained in good physical condition, that lack perforations, grouting cracks, gaps or other pathways for the rapid downward migration of surficial liquids. ALWI also recommends continued protection of the wellheads from vehicular hazards and grading to redirect stormwater away from the wellhead. Even in this confined aquifer, setting consideration should be given to storm drain labeling and sign postage near the production wells. Water treatment chemicals should be stored using a means that provides for secondary containment should a leak or spill occur. Appropriate signs prohibiting dumping should be posted throughout Zone 1 and 2A WHPAs to the degree feasible.

6. **Early Warning Monitoring Well** – ALWI recommends that one or more shallow irrigation well be maintained and used for periodic water quality sampling by the Town. Analytes should include nitrates, phosphorous, fecal coliform bacteria, *E. coli.* and volatile organic compounds. Semi-annual sampling should be considered for this first year, reducing to annual and then triennial analyses once a baseline has been established. ALWI recommends that the monitoring well be reconstructed with an adequate grout seal. Berms and/or curbing should be considered as an additional means to prevent surface water from entering the aquifer along the outside of the well casing. The well grouting should be inspected periodically for cracks, pits or deterioration and repaired upon detection of any inadequacies.

7. **Sewage Sludge Management and Source Reduction** – The Town should investigate the feasibility of relocating the sewage sludge disposal field outside the WHPA. Until such relocation is achieved, the Town should advise MDE sewage sludge officials of the delineation and continue to work closely with MDE sewage sludge permitting authorities in reducing the risk of groundwater contamination risk from the sludge being applied. Strict adherence to permitting requirements is one means of helping to mitigate this risk.

8. **Community Outreach to Agricultural Land Owners and Tenant Farmers in Zone 2A** - Sharptown should implement a WHPA-wide community outreach and awareness program, concentrating on agricultural land owners and users in Zone 2A. ALWI recommends that assistance be solicited from local agricultural extension officials in contacting and educating affected parties as to the consequences of certain incompatible options. ALWI also recommends that informal refuse disposal practices in the WHPA cease. The dumping areas should be cleaned up to the degree financially feasible. “No dumping”, signs should be posted at and near this refuse disposal area.

9. **Adopt MDE Model Wellhead Protection Ordinance** – Sharptown should consider adopting the model wellhead protection ordinance (Appendix E), at minimum to apply to Town areas within Zone Nos. 1 and 2A.

10. **Notify Wicomico County Planning and Zoning Department** – Municipal officials believe that little if any development pressure exists in or near Sharptown. Nevertheless, local economic conditions may change and development may occur. Future land uses outside the corporate limits of the Town are under the approval jurisdiction of the Wicomico County Department of Planning and Zoning. ALWI recommends that the County be furnished a copy of this Plan and requested to manage the review and approval process for future land uses within the WHPA in accordance with the recommendations herein.

11. **Use Discretion in Roadway and Parking Lot Deicing** – Restrictions in the use of conventional road salt should be predicated on existing sodium and chloride concentrations in the shallow aquifer. A wise precaution would involve the use of non-chemical abrasives to replace some salt usage in Zone 1.

12. **Perform Code Inspection** – Sharptown should embark on a program of periodic plumbing inspections to identify and require the correction of cross-connections. This program would also help to identify other visual evidence of inadequate and/or improper maintenance that could contribute to either a groundwater or a distribution system contamination hazard.

ALWI notes that Zone 2A extends across the Mason-Dixon line, into southwestern Delaware. From a standpoint of pragmatism in WHPA management, municipal interests may wish to consider truncating the eastern extent of Zone 2A at the state line. Alternatively, Sussex County Planning and Zoning and agricultural extension officials would need to be contacted to engender support in protecting the eastern portion of Zone 2A from incompatible land uses and development activities.

5.2 CONTINGENCY PLANNING

According to MDE wellhead protection guidance documents, an effective contingency plan should have six key components: inventory of threats; design of response; assignment of responsibilities; identification of resources (logistical, technical, and financial); periodic review and updates and public awareness. Threats have been inventoried and public awareness measures suggested earlier in this document.

ALWI suggests the following step-wise procedures for implementation in the event of an acute threat of water supply contamination:

1. **Confirm Source / Notify Owner / Reduce Threat –** Sharptown should verify the nature, source and degree of contamination within the aquifer and/or water supply system. Presuming that the threat is to the shallow wells, first the Town should close those wells and use the Nanticoke aquifer wells, only. The owner(s) (i.e., potentially responsible party) of the leak or spill should be identified and then notified so that corrective action can be taken. At the same time, contamination threat reduction measures should be evaluated and implemented to mitigate degradation of the water supply and any associated health risks (e.g.

distribution system flushing, sampling, spill clean-up, equipment maintenance and cleaning as necessary).

2. **Notify Customers / Reduce Demand –** The detection of contamination warrants public notification before the contamination reaches customer connection(s) to the service. Depending on conditions observed, it may be necessary to advise customers to reduce demand, boil water or in a worst-case scenario, refrain from unnecessary water supply usage (e.g. use bottled water for cooking and drinking, bathe "at your own risk", etc.).

3. **Retrofit for Treatment –** If detected, the degree and nature of contamination may necessitate treatment prior to distribution (centralized treatment) or treatment within each household (point-of-use treatment). A quick cost evaluation of the treatment process options would aid in the decision-making process.

4. **Develop Alternative Water Source –** ALWI anticipates that careful monitoring and contingency planning herein will largely preclude catastrophic water supply problems. In the event that water quality within production wells degrades beyond effective treatment (or should the cost of treatment prove to be exorbitant) alternative sources of water may need consideration. Assuming that the shallow wells are affected, ALWI would further recommend construction of a new supply well in one of the deeper freshwater aquifers. To limit interference potential and improve aesthetic quality, consideration could be given to developing the replacement supply in the deeper Piney Point aquifer. The new well should be constructed in a manner to isolate the newly penetrated aquifer from overlying contamination (i.e., adequate grouting, casing to screened interval, etc.).

Close cooperation of the following entities would be necessary for the timely and cost-effective address and resolution of a potential contamination occurrence: The Town, the Wicomico County Health Department and MDE. Sharptown should establish a financial reserve to fund contingencies and should remain abreast of MDE grant programs regarding the same. A list of contact names, addresses, telephones, faxes and pager numbers should be developed and kept current. Copies should be provided to Sharptown (facilities and administrative personnel), Sussex and Wicomico Counties (the DPW, Emergency Response and Environmental Health), the U.S. Department of Agriculture's extension agents based in Salisbury, MD and Georgetown, DE, and MDE (including WSP and Emergency Response). The list should be reviewed and updated annually for currency.

5.3 POTENTIAL FOR CHANGES IN WHPA DELINEATION OR PLAN ELEMENTS

Future increases in pumping rates, if achievable, or changes in the distribution of withdrawals (i.e., shallow vs. deep aquifer use) may draw waters from areas not previously within the capture zones and may require an increase in the size of the WHPAs. Also, actual long-term operational capacities may differ from projections made based on limited operational data. There is no substitute for accurate long-term testing, and such testing can be designed and executed cost-effectively using existing pumps. Absent such data, however, contingency plans should be developed and implemented to address the possible gradual onset of future supply shortfalls (whether or not growth in Sharptown water demand occurs) as follows:

1. **Conserve Water** – ALWI recommends the use of ultra low-flow plumbing fixtures in all newly constructed facilities in the service area.

2. **Plan for Shortfalls** – As periodically necessary based on drought conditions or future supply/distribution issues of a transient nature, a means to place all Sharptown customers under water use restrictions should be developed (i.e., either voluntary or mandatory water conserving measures depending on the severity of the low supply condition). Of course, new hydrogeologic data could also refine the delineations.

6.0 CONCLUSIONS

In preparing the conclusions enumerated below, ALWI has utilized its best level of effort consistent with its professional standards, present scientific judgment and knowledge. ALWI has upheld accepted industry practice and prepared this report within the budgetary and work scope limitations set forth in its contract with Sharptown. Subject to this provision and the assumptions and exclusions specified and mutually agreed in ALWI's contract with Sharptown and/or referenced herein, ALWI's conclusions follow:

1. **WHPA Delineation** - ALWI delineated a four-zone WHPA following methods prescribed and approved by MDE. The results are shown pictorially in Figure 1. In performing the delineation, conservatism was preserved without undue sacrifice in the utility of the Plan. The technical work supporting the delineation, particularly the distribution of shallow vs. deep aquifer use, should be reviewed triennially and updated as necessary.

2. **Contamination Hazards** – ALWI identified and catalogued existing and potential contaminant hazards in each WHPA zone. Not all hazards are equal in immediacy, proximity and condition. Hazards are mapped on Figure 1.

3. **Management Tools and Contingency Plans** - Herein ALWI also presents several suggestions for proactive management and risk reduction of a future contamination occurrence in the WHPA. Generally, these center on source reduction, risk awareness, emergency and contingency planning programs.

7.0 RECOMMENDATIONS

This wellhead protection plan is intended as a dynamic document, requiring regular updates and refinements so as to continue to fulfill its goals of defensibility and usability. In light of the information presented herein, ALWI offers the following recommendations:

1. **Periodically Review and Update Delineation** – The delineations herein are predicated on a nested set of assumptions regarding the local and regional hydrogeologic framework. Changes in the magnitude and distribution of groundwater withdrawals, both from the system's production wells and from other nearby wells, would change the delineation. Also, the availability of additional hydrogeologic data could allow refinement of the existing delineation work. ALWI recommends that the delineation work be checked and reverified triennially.

2. **Periodically Review and Update Contamination Hazard Inventory** - The inventory of contaminant hazards presented herein represents ALWI's best understanding of the local point-source hazards as of August 2000. Land uses can change rapidly. ALWI recommends that the contaminant hazard inventory herein be updated triennially.

3. **Management Tools**– ALWI herein suggests that local ordinances and protective covenants, combined with community awareness and public outreach measures likely afford the desired level of WHPA management. These measures should be periodically reviewed for effectiveness and adjusted based on local conditions and issues.

8.0 SELECTED REFERENCES

Boulding, J.R., 1994, Groundwater and Wellhead Protection Handbook: United States Environmental Protection Agency.

Chapelle, F.H., 1985, Hydrogeology, Digital Solute-Transport Simulation and Geochemistry of the Lower Cretaceous Aquifer System near Baltimore, Maryland: Maryland Geological Survey Report of Investigations No. 43, 120p.

Cushing, E.M., I.H. Kantrowitz and K.R. Taylor, 1973, Water Resources of the Delmarva Peninsula: U.S. Geological Survey Professional Paper No. 822, 58p.

Maryland Department of the Environment, 1991, Wellhead Protection Program.

Maryland Department of the Environment, 1997, Model Wellhead Protection Ordinance.

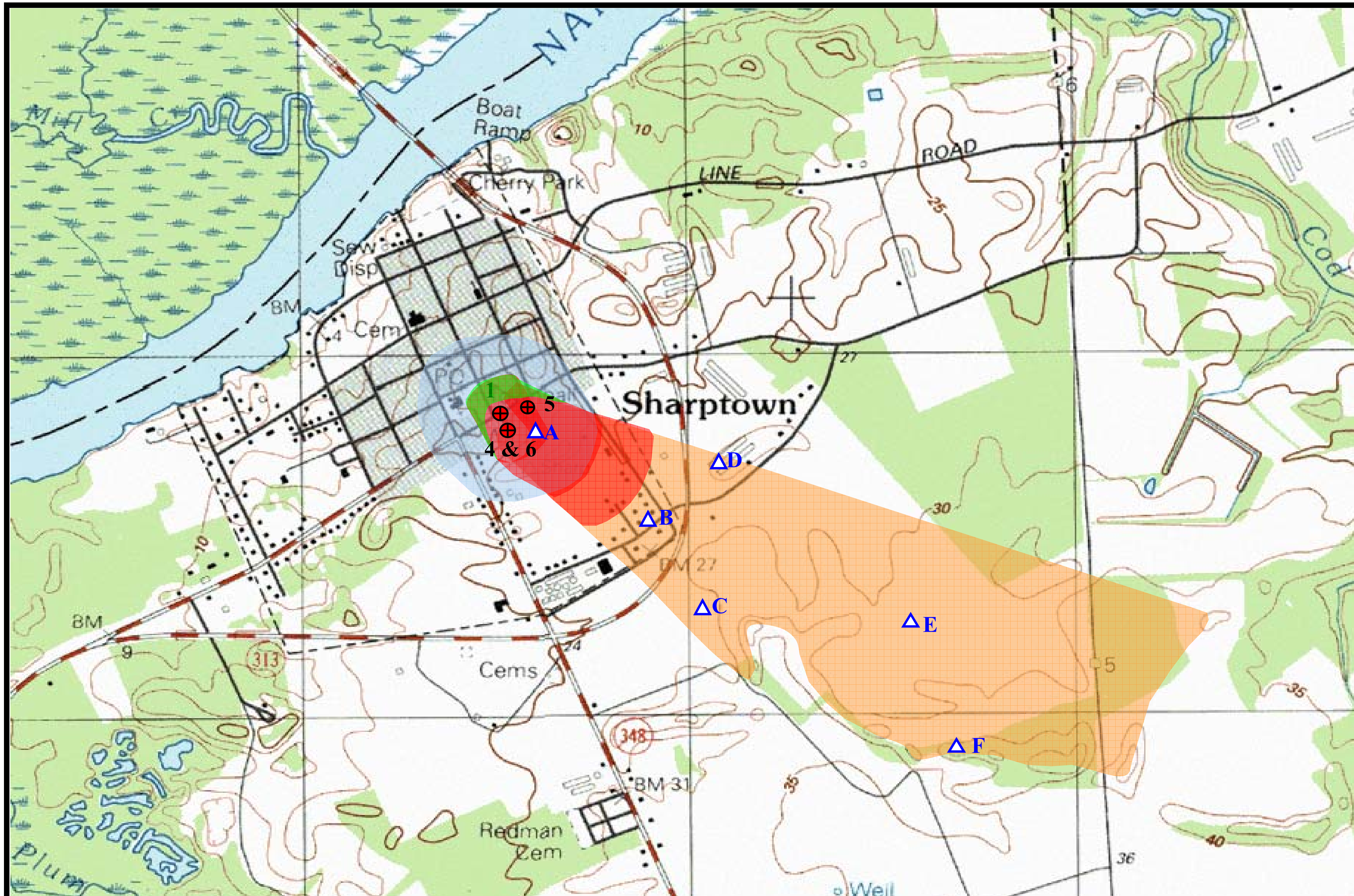
Maryland Department of the Environment, Public Drinking Water Program, 1998, Source Water Assessment for the Town of Rock Hall, 4p.

Maryland Department of Environment, 1999, Source Water Assessment Guidance Document.

Rasmussen, William C. and Turbit H. Slaughter, 1955, The Ground-Water Resources *in* The Water Resources of Somerset, Wicomico and Worcester Counties: Maryland Department of Geology, Mines and Water Resources (Maryland Geological Survey) Bulletin 16, 533p.

Smigaj, M.J., Saffer, R.W., Starsoneck, R.J., and Tegeler, J.L., 1998, Water Resources Data Maryland and Delaware Water Year 1997, Volume 2, Groundwater Data: United States Geological Survey Water Data Report MD-DE-97-2, 549 p.

United States Environmental Protection Agency, 1974, Safe Drinking Water Act, Amended 1986.



Final Draft

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EXPLANATION:

△ potential contamination hazard (see Section 4.0 of report)

⊕ municipal water supply well

WHPA Zone 1

WHPA Zone 2A

WHPA Zone 2B

WHPA Zone 3

APPROXIMATE SCALE:

0 1000 2000

Notes:

1 - Base map imported from digital USGS topographic quadrangle map for Sharptown, MD (1992) provided by Maptech, Inc.

2 - Delineations performed using EPA WHPA Code (Columbia aquifer) and Volumetric Flow Equation (Nanticoke aquifer). See report for details.

3 - This figure is integral to a written report and should only be used in that context.

4 - This figure is solely intended to facilitate regulatory review and is not intended to be used for boundary verification or survey control purposes.

Client:

COMMISSIONERS OF SHARPTOWN

Project No. WI7N063

ADVANCED Land and Water, Inc.

Global Environmental Solutions

Project:

SOURCE WATER ASSESSMENT FOR SHARPTOWN, MARYLAND

Prepared in Pursuant to the Requirements of:

MARYLAND DEPT. OF ENVIRONMENT WATER SUPPLY PROGRAM

Figure 1.

Wellhead Protection Map for Sharptown

February 21, 2001

Delineating Wellhead Protection Areas Using the Volumetric Flow Equation
Description of Methodology

The Maryland Department of the Environment (MDE) Source Water Assessment Guidance Document (1999) recommends the use of a Volumetric Flow Equation (VFE), informally termed the "Florida Method" to delineate wellhead protection areas (WHPAs) in the confined aquifers of the Atlantic Coastal Plain. Analytical techniques such as the VFE are mathematical simplifications of more complex hydrogeologic systems.

The degree to which analytical models can be relied upon for defensible predictions of the fate and transport of potential contaminants in the subsurface depends on (1) the quantity and quality of raw data available and (2) the degree to which the simplifying assumptions inherent in the chosen analytical solution plausibly mimic naturally occurring conditions. The VFE is one of several analytical techniques that predict aquifer behavior. These techniques rely on a set of assumptions first stated by Theis (1935)[1].

The VFE, as recently summarized in Boulding (1994), utilizes a volumetric equation that results in an areal estimate of the radial capture zone. Conceptually, the water demand of the well (typically on a 1-year or 10-year basis) must be satisfied by the interstitial water within the aquifer material comprising the disk. The disk has a uniform porosity, its thickness is equal to the height of the well screen, and its radius is proportional to the pumping rate. Mathematically, the Florida Method equation for radial time-based particle travel distance is expressed as follows:

$$\text{Radius of Capture Zone} = \sqrt{\frac{\text{Pumping Rate (ft}^3\text{/yr) * Travel Time (yr)}}{\text{Pi * Porosity * Screened Interval (ft)}}}$$

ESTIMATE OF RADIAL CAPTURE

ALWI executed the model by first assigning values to each of the variables in the above equation as follows:

1. **Pumping Rate** – ALWI assigned groundwater withdrawal rates to each of the deep production wells in the modeled area such that the overall municipal withdrawal rate from the deep aquifer was 110% of the quantity reported for this aquifer from the last full year that data were available. This adjustment provides for metering and reporting inaccuracies as well as for modest growth in water demand and/or increases in distribution leakage typical for aging utility infrastructure.
2. **Travel Time** - ALWI executed the VFE equation for both 1- and 10-year travel times, resulting in concentrically sub-radial capture zones.
3. **Porosity** – Fetter (1994) references a range of typical porosities for sandy aquifers from 0.2 to 0.3. ALWI executed the VFE equation, each of these porosities and ultimately elected to use a porosity value of 0.2 for maintenance of conservatism.
4. **Screened Interval** - The heights of the screened intervals were determined from the MDE well completion reports.

CONSIDERATION OF AMBIENT FLOW

ALWI recognized that the sub-circular zones generated by the Florida Method solutions do not account for the direction and velocity of ambient groundwater flow. Further consideration of ambient groundwater flow in the deep aquifer was not possible because of the paucity of control data.

[1] Theis (1935) developed analytical equations of groundwater flow. Use of these equations and their derivatives requires assumptions that the aquifer of interest is homogeneous, isotropic, infinitely laterally extensive, fully penetrated by well(s) pumping at 100% efficiency (i.e., without well loss), receives no recharge, and that the well screens the entire thickness of the aquifer.

Delineating Wellhead Protection Areas in Unconfined Aquifers
Description of Methods Used

The Maryland Department of the Environment (MDE) Source Water Assessment Guidance Document (1999) recommends the use of semi-analytical groundwater flow modeling, combined with hydrogeologic mapping, to delineate wellhead protection areas (WHPAs) in unconfined aquifers of the Atlantic Coastal Plain. Semi-analytical models are mathematical simplifications of more complex hydrogeologic systems. The degree to which analytical models can be relied upon for defensible predictions of the fate and transport of potential contaminants in the subsurface depends on (1) the quantity and quality of raw data available and (2) the degree to which the simplifying assumptions inherent in the chosen semi-analytical model plausibly mimic naturally occurring conditions.

The semi-analytical model in most prevalent use for delineating wellhead protection areas is called the "Wellhead Protection Area Delineation Code" by Blandford and others (1993). This model is informally referred to as the "EPA WHPA Code" and is one of several semi-analytical techniques that predict aquifer behavior under a somewhat idealized set of assumptions that include the following: (1) groundwater flow in the aquifer is time-independent and (2) groundwater flow occurs only in a two-dimensional plane. Other assumptions govern application of the underlying algorithms and were first stated by Theis (1935)[1], except that the model can accept simple stream boundaries, barrier boundaries and areally constant recharge.

Key input parameters include aquifer transmissivity, porosity, pumping rate, hydraulic gradient and saturated thickness. Input parameters and data sources for each of these parameters were as follows:

1. **Transmissivity** – Transmissivity values were derived from the time-drawdown relationships in available pumping test data (albeit using the Cooper and Jacob [1946] confined aquifer solution) and confirmed through available literature, including Bachman (1984). Transmissivity values between 5,000 ft^2/day and 30,000 ft^2/day were evaluated with a final value of 18,000 ft^2/day selected for use.

2. **Porosity** – Unconfined aquifers on the Atlantic Coastal Plain typically have effective porosities that range from 20% to 30%. No local field data were available. Accordingly, ALWI performed sensitivity analysis and found that lower porosities lent greater conservatism to the overall evaluation. Thus, ALWI used a porosity of 20%.

3. **Pumping Rate** – ALWI was provided production records from 1999 to determine pumping rates for the wells (Figure C-2). ALWI used 110% of the quantity reported to have been withdrawn from the Columbia aquifer. This adjustment provides for metering and reporting inaccuracies as well as for modest growth in water demand and/or increases in distribution leakage typical for aging utility infrastructure.

4. **Hydraulic Gradient** – Little published data exists on the hydraulic gradient in the area of Sharptown. To compensate, ALWI determined the gradient by collection of independent data. A water level measurement was made in an existing shallow well used for lawn irrigation. This was compared to the known head of the Nanticoke River, and divided over the distance in the direction of predicted groundwater flow for a resultant gradient of 0.0015 ft/ft (see annotations on

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[1] Theis (1935) developed analytical equations of groundwater flow. Use of these equations and their derivatives requires assumptions that the aquifer of interest is homogeneous, isotropic, infinitely laterally extensive, fully penetrated by well(s) pumping at 100% efficiency (i.e., without well loss), receives no recharge and that the well screens the entire thickness of the aquifer.

Figure C-1). ALWI also considered use of more distant water level data but doing so seemed less reliable so the effort was abandoned. Similarly, mere use of the head differential between the static water levels in the production wells and the surface of the Nanticoke River seemed less conservative because the steep topography between the wells and the river is not reflective of the gentle grades within the WHPA.

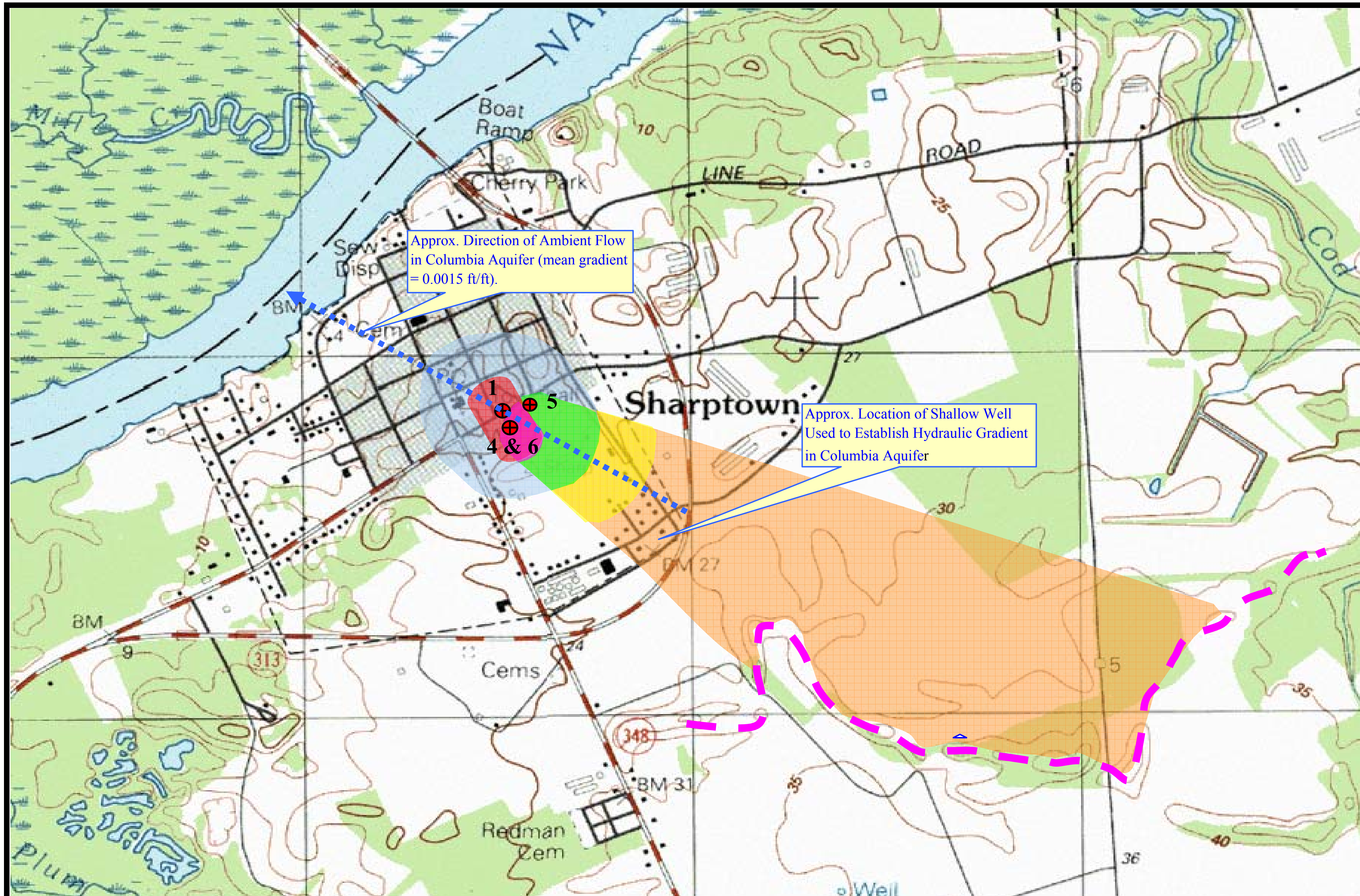
5. **Saturated Thickness of Aquifer** – ALWI used 64 feet as published by Bachman (1984) for the local thickness of the Columbia aquifer.

With the above input parameters, the model returned long and narrow cylindrical WHPAs. For added conservatism, ALWI evaluated the likely spatial uncertainty associated with the ambient groundwater flow direction and the likely numerical uncertainty associated with the aquifer properties listed above.

- **Spatial Uncertainty** - ALWI assumed that the Columbia aquifer discharges to the Nanticoke River with flow lines sub-orthogonal to the main stem of the River. Horizontal variance and imprecision in this flow direction was considered to be 30^{o} based on shallow monitoring well networks maintained near streams in other locations[2]. Accordingly, the north-to-south width of Zone 2A is a function of this directional uncertainty and its possible seasonal fluctuation. Better data could result in the widening, narrowing and/or rotational movement of Zone 2A by (perhaps) as much as several degrees.

- **Numerical Uncertainty** – ALWI evaluated the sensitivity of the delineated area (size and shape) to variances of each aquifer property within a range of typically expected values. Factual information (e.g., published aquifer parameters, well screen heights, comparisons to the approved SWAP for Hurlock, etc.) placed end member constraints on the degree of variance of each variable. Final parameters that were selected reflect ALWI's best overall judgment of likely values, tempered by appropriate conservatism.

[2] Three shallow monitoring wells located in the floodplain of Herring Run were gauged and monitored quarterly for several years. During dry periods, groundwater flow was perpendicular to Herring Run. However, during wet periods groundwater flow rotated down gradient approximately 30^{o}.



Draft

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EXPLANATION:

⊕ municipal water supply well

topographic constraint on extent of WHPA in southeastern direction

WHPA Delineations - Nanticoke Aquifer

1-year capture zone

10-year capture zone

WHPA Delineations - Columbia Aquifer

1-year capture zone

10-year capture zone (modified for topography; see report for details)

Overlapping Delineated Areas

1-year capture zone (both aquifers)

1-year capture zone (Columbia) and 10-year capture zone (Nanticoke)

APPROXIMATE SCALE:

0 1000 2000

Notes:

1 - Base map imported from digital USGS topographic quadrangle map for Sharptown, MD (1992) provided by Maptech, Inc.
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Figure C-1

Zonal WHPA Delineations

January 15, 2001