Alternative Water Supply Feasibility Study

Monhegan Plantation
September 2020
Revised July 2021

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This report was prepared for Monhegan Plantation under award CZM NA18NOS4097419 to the Maine Coastal Program from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce administered by the Municipal Planning Assistance Program at the Maine Department of Agriculture, Conservation and Forestry. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the Department of Commerce.

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1.0 INTRODUCTION

1.1 General

Monhegan Island is located approximately 10 miles off the coast of Maine. Less than one square mile in area, Monhegan is joined by another small island known as Manana, located just a few hundred feet across the harbor, along with several islets. The closest mainland landmasses include Pemaquid Point and Port Clyde, both roughly equidistant from the island. The island maintains a year-round population of approximately 50 residents, swelling to well over 1000 people in the summer, when seasonal residents and visitors arrive via one of the several ferry lines from the coast of Maine. The island does not rely on the mainland directly for its major utilities, as it maintains its own electrical supply, water company, and fire department.

The Monhegan Water Company is run by several of the island's residents and supplies seasonal water via a surface level distribution system to many of the islands residents and businesses. During the off-season, the water system is shut down and water is supplied through a series of privately-owned drilled wells, as well as by basement cisterns. Unlike some of its island neighbors in Maine, Monhegan has not experienced significant issues with salt-water intrusion in its water supply. Nevertheless, the island's residents and leadership are acutely aware that changing climactic conditions and summer demands on the water system put the island at risk of this phenomenon.

The residents and leadership of the island would like to make several determinations about its present and future water supplies, including the current threat of salt-water intrusion, as well as the viability of expanding the use of the bedrock aquifer to serve the island in a more widespread capacity. Figure 1-1 shows a general location map of the island, with parcels, wells observed for this report, and potential well locations derived from the study.

1.2 Project Funding

The Maine Department of Agriculture, Conservation & Forestry's Municipal Planning Assistance Program (MPAP) and the Maine Department of Marine Resources Maine Coastal Program (MCP) together administer the Coastal Community Grants program. Coastal Community Grants are an "element of the MPAP's work to encourage and promote efforts of coastal communities and regional planning organizations pursuant to the goals of the Growth Management Act (M.R.S.A. 30-A, Chapter 187) and Coastal Management Policies (M.R.S.A. 38, Chapter 19). The grants are for municipal and regional projects in Maine's coastal zone." Funding for the grants comes from Maine Coastal Program's annual grant from the National Oceanic and Atmospheric Administration (NOAA).

Eligible projects must be designed to address one or more of the five priority goals of the Maine Coastal Program:

- Ensuring Sustainable, Vibrant Coastal Communities
- Improving Coastal Public Access
- Addressing the effects of land use activity on water quality
- Restoring Coastal Habitats
- Preparing for coastal storms, erosion and flooding, coastal hazards

The subject study addresses the first and fifth goals listed above.

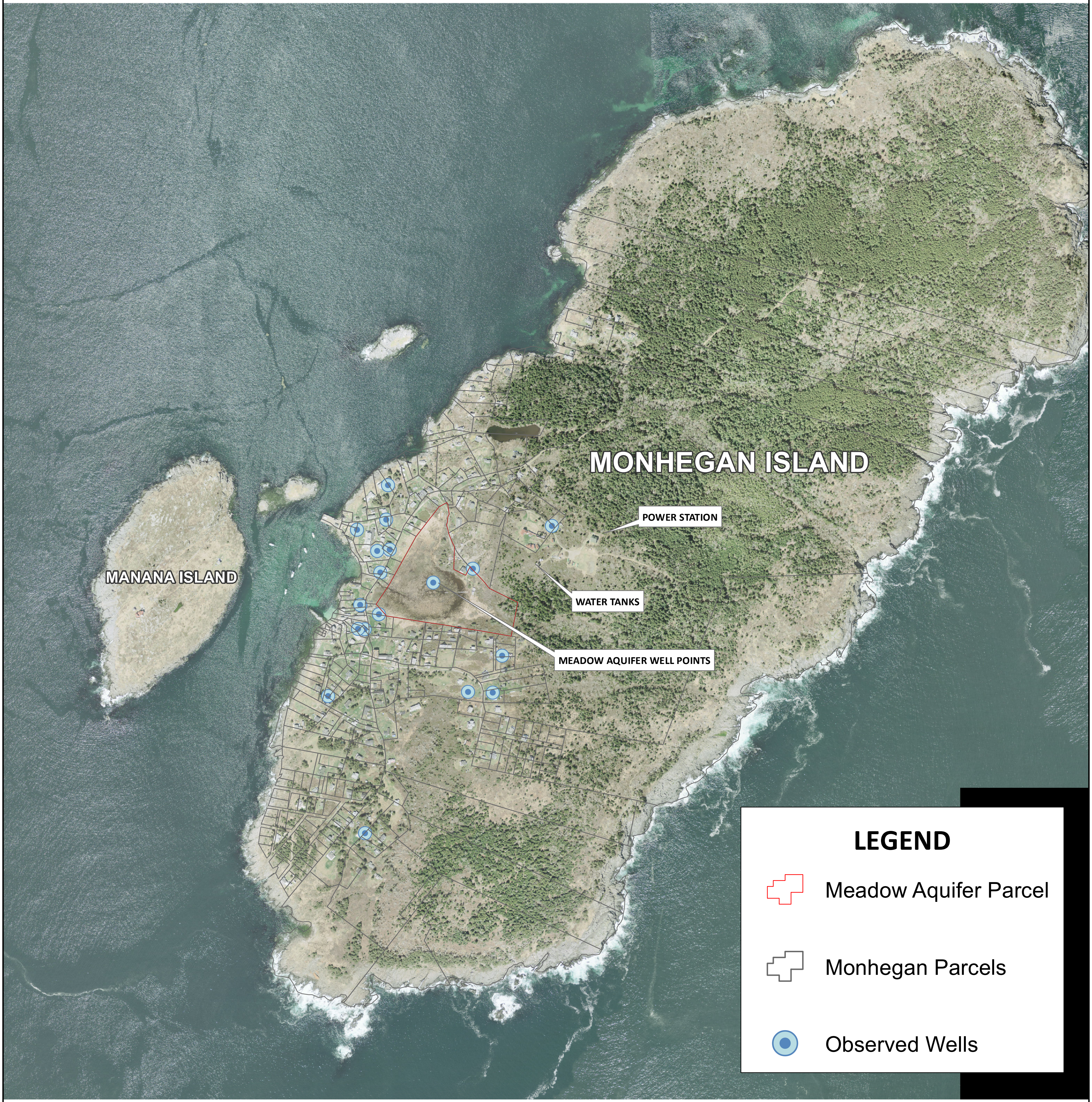

Figure 1-1: Location Map - Monhegan Island

Alternate Water Supply Feasibility Study
Monhegan, Maine

0 0.05 0.1 0.2
MILES
1 in = 750 ft

N

MILONE & MACBROOM
99 Realty Dr
Cheshire, CT 06410
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1.2.1 Funded Tasks and Personnel

The funding that enabled development of the subject report was organized into three areas:

- Characterization of the Meadow aquifer and evaluation of the risk of saltwater intrusion;
- Characterization of the bedrock aquifer relative to existing private well water quality and yields; and
- Characterization of the bedrock aquifer relative to potential future water supple wells for Monhegan Water Company.

These three tasks collectively advance the understanding of the island's current water supply and future water supply needs. The Plantation retained SLR Consulting (known as Milone & MacBroom, Inc. until late 2020) to conduct the technical services necessary for this contract. The three individuals who executed the work are the core team members of the firm's water supply service:

- David Murphy, PE, Certified Floodplain Manager (CFM) – David has degrees in geology and hydrology, and serves as the firm's Manager of Water Resources Planning. In this position, he oversees water supply planning and climate change resiliency services. While these are typically perceived as unrelated fields, they intersect for this study. David is also the firm's senior hydrogeologist and personally conducted the bedrock fracture mapping for the study.
- Matthew Rose – Matt has a degree in natural resources management and served as the field scientist and primary author for the subject study.
- Scott Bighinatti, CFM – Scott has degrees in natural resources management and hydrology, and is the firm's primary groundwater flow modeler. He conducted the groundwater modeling for this study and wrote sections of the report related to the modeling.

1.2.2 Tasks to Address with Future Funding

Future funding may be secured by the Plantation to conduct exploratory drilling, set aside lands for future water supply development, or modernize the Meadow aquifer water supply system.

2.0 SALTWATER INTRUSION MODELING ASSESSMENT OF MEADOW AQUIFER

A numerical groundwater model of the Meadow Aquifer was developed to estimate and predict the location and movement of the interface between the freshwater aquifer and the brackish zone. Existing geologic mapping, aerial photography, an elevation survey, and very limited field work were used as the basis for model development. The model was used to test for potential saltwater intrusion under a limited range of possible future sea level rise scenarios. The goal was to determine if the Monhegan Water Company is at a greater-than-low risk for future saltwater intrusion due to sea level rise, and if Monhegan Water Company needs to consider various monitoring program configurations and frequencies or additional modeling that could help demonstrate changing risk over time.

2.1 Numerical Methods

The numerical three-dimensional model program known as MODFLOW 2000 developed by the United States Geological Survey was used to simulate the overburden Meadow Aquifer. The particular version of MODFLOW 2000 to be used for this analysis is compiled with recent versions of Groundwater Vistas, a Microsoft Windows-based platform including pre- and post-processors and executable versions of MODFLOW 2000, MODPATH, MT3D, SEAWAT2000, and several other programs. Numerical model files associated within the simulations in this section are provided on the compact disc in Appendix A.

2.2 Model Characteristics

2.2.1 Dimensions and Discretization

The study area was divided into a numerical model grid that has 54 rows and 84 columns extending 955 feet in the southeast-northwest direction and 1,230 feet in the southwest-northeast direction. The columns are aligned 18 degrees to the east of north, generally consistent with the outlet stream leaving the meadow.

The model domain includes the entire unconsolidated stratified aquifer of appreciable thickness as delineated by Timson (1991). The model domain extends westward to include the Monhegan pier area although this area was ultimately not included as active cells. The model domain is sufficiently large to prevent interference between the well points and the model boundaries. Figure 2-1 presents the model domain and model boundary conditions.

Minimum grid spacing (model cell dimensions) is 10 feet by 10 feet in the center of the study area near the well points, and maximum grid spacing is 40 feet by 45 feet in the northwestern corner of the model. The ratio of spacing between adjacent rows and columns is less than 1.5 ensuring model stability.

2.2.2 Layers and Elevations

The numerical model has three layers corresponding to the depositional units of the Meadow aquifer. Refer to Figure 2-2a for a representation of the aquifer as developed by Timson (1991) which was used to generate model layering.

- Layer 1 corresponds to the peat materials present in the upper portion of the Meadow Aquifer. This layer was modeled as an unconfined aquifer.
- Layer 2 corresponds to the clay materials underlying the peat but located above the glaciomarine sand.
- Layer 3 corresponds to the glaciomarine sand in the lower section of the Meadow Aquifer.

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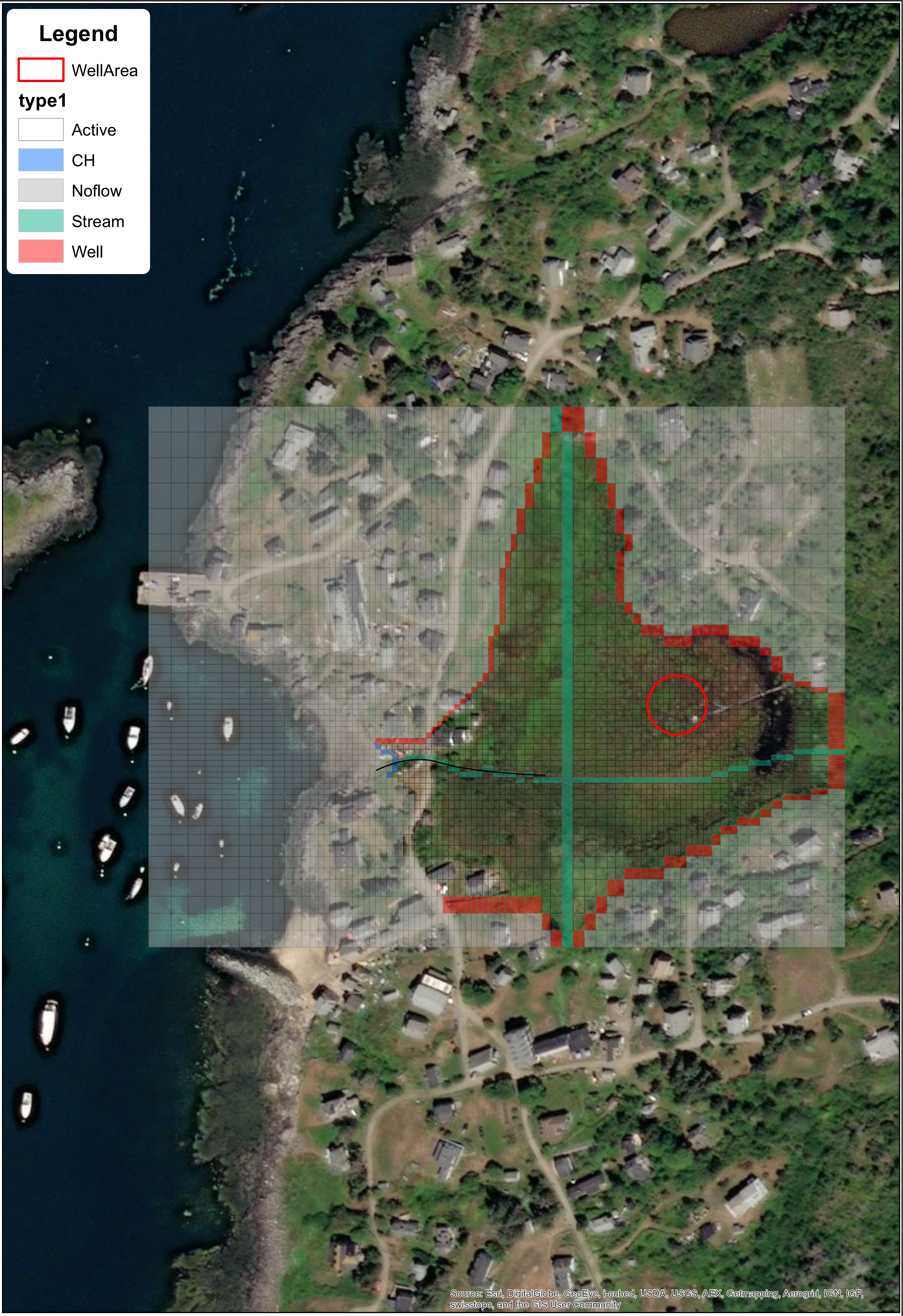

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

SHEET NAME
FIG 2-1

PROJECT NO.
6493-02

DATE
JULY 2021

SCALE
1 inch = 150 feet

DESIGNED SJB
DRAWN SJB
CHECKED DM

MODEL BOUNDARY CONDITIONS

ALTERNATE WATER SUPPLY FEASIBILITY STUDY

MONHEGAN ISLAND PLANTATION
MONHEGAN, MAINE

DESCRIPTION	DATE	BY

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N
E
W
S
80
Feet

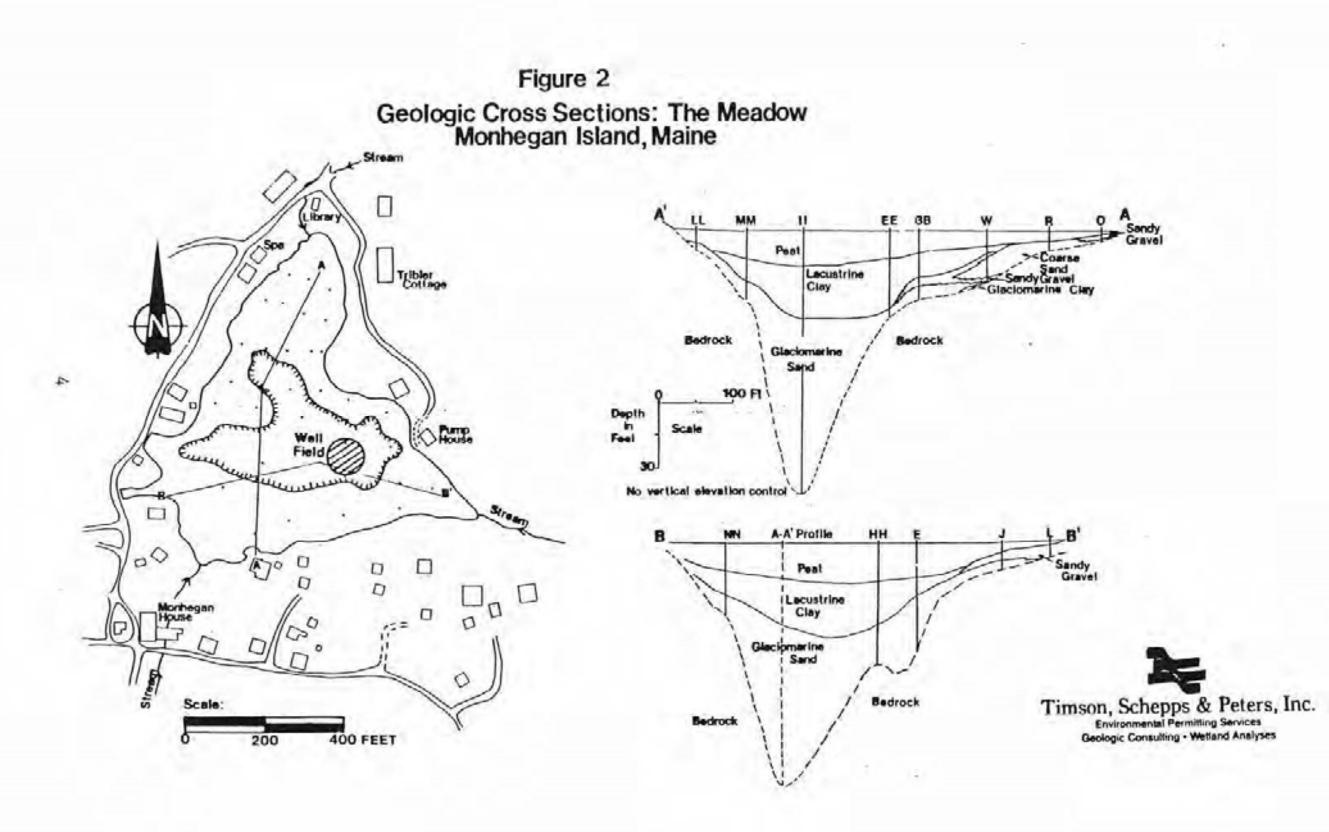

Figure 2-2a
[Figure 2 from Timson Report]

Layer 2 and Layer 3 were both modeled as confined model layers. In addition to the deposits described above, a contiguous unit of coarse-grained beach & washover deposits was modeled in each layer to separate the Meadow aquifer from the shore as depicted on Figure 2-2b (Figure 6 of the 1991 Timson report) following this page.

Limited elevation survey was performed by the consultant's environmental scientists to tie the Timson work into the NAVD88 elevation datum using the 2019 "Topographic Survey of Main Street, Wharf Hill Road & Swim Beach" developed by Little River Land Surveying, Inc. as a basis for comparison. This field survey was conducted using standard survey equipment, but the data generated does not have an accuracy standard and should not be represented as formally surveyed elevation data. Model layer elevations were developed and interpolated within Groundwater Vistas to create the layer bottoms, with the interpolated bottoms adjusted based on site-specific information where appropriate. The top of the model was defined based on 2-foot LiDAR topography shapefiles generated by the State of Maine, with site-specific adjustments based on the survey data where appropriate.

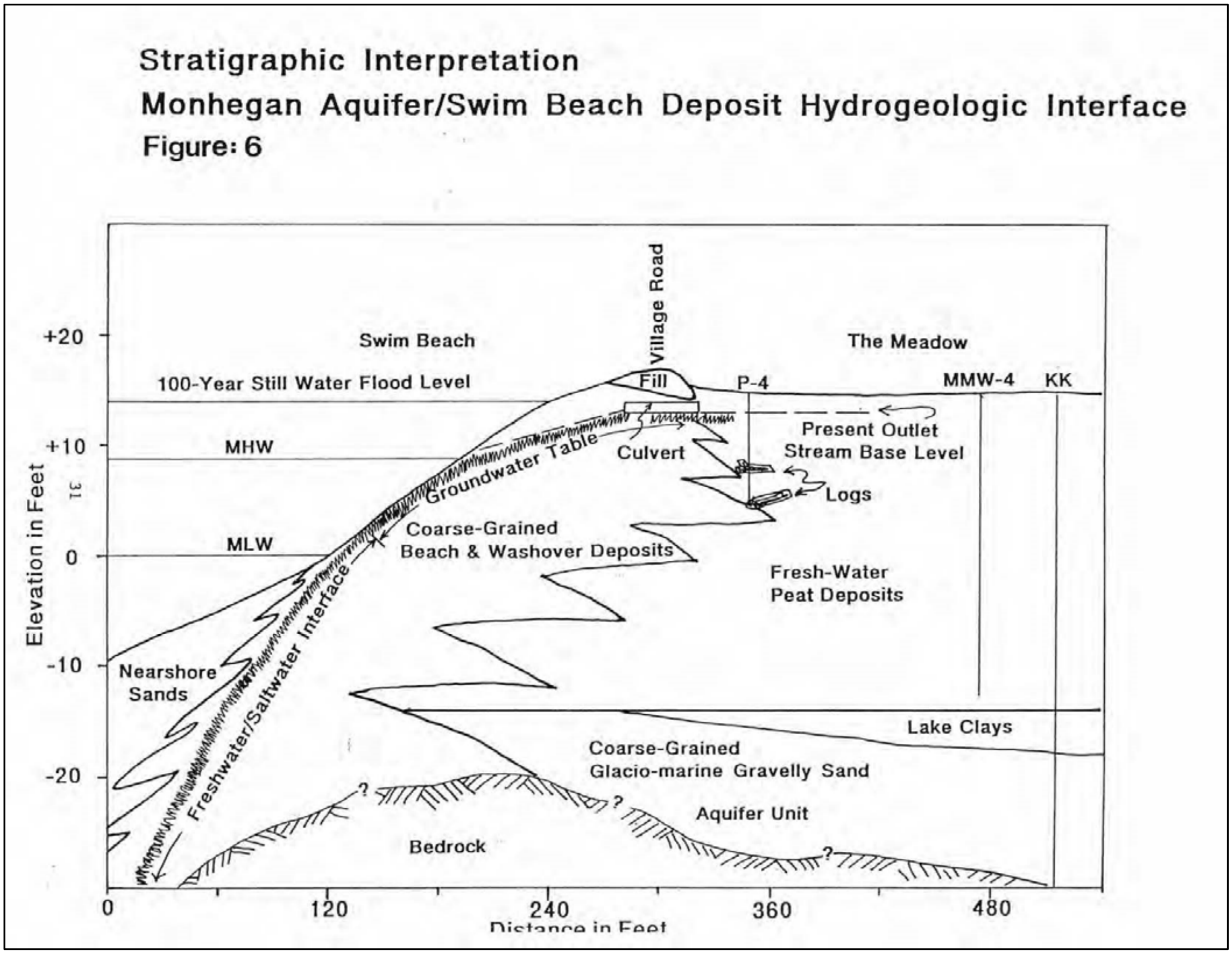

Figure 2-2b
[Figure 6 from Timson Report]

2.2.3 Boundary Conditions

The northern, eastern, and southern boundaries of the numerical model were set to correspond to the boundaries of glacial till or thin overburden materials in the outer reaches of the Meadow Aquifer. The western boundary was set based on the shoreline at Swim Beach. Note that Timson (1991) suggested that a second direct hydrogeologic connection to the shoreline may occur through the area near Square House. During review of the model by the Monhegan Project Manager in May 2020, Mr. Dalrymple stated his belief that the majority of the area west of Main Street and between the Meadow outlet stream south to Square House was primarily bedrock outcrop, and any shallow overburden in this area was likely to be unsaturated. Thus, the area west of Main Street was deactivated in the model with the exception of the area near the Meadow outlet stream.

Boundary conditions used in the model include No-Flow cells to account for the extent of glacial till, thin aquifer materials, and unsaturated areas; injection (flux) cells surrounding the majority of the outermost reaches of the No-Flow cells to account for groundwater input from adjacent bedrock and till areas; Stream cells to model the movement of water through the Meadow and to the outlet stream; and Constant Head cells to model the Atlantic Ocean at Swim Beach. All boundary conditions were added to Layer 1, with Constant Head cells also included in Layer 2.

2.2.4 Hydrologic Stresses, Sources, and Sinks

The model was programmed to generally represent 1990 conditions in order to make use of the Timson (1991) data. Stresses, sources, and sinks for the model include the following:

- Annual precipitation was noted to be approximately 49 inches by Timson (1989).
- Flux across till boundaries was calculated based on the upstream drainage areas. The flux was initially set to be 16% of 49 inches precipitation for the steady-state model. This percentage considers subtractions from evapotranspiration in till areas as well as the fact that runoff from till areas is typically up to three times higher than on stratified glaciofluvial deposits.
- Recharge to active model cells was initially set to be 40% of 49 inches of precipitation for the steady-state model.
- Evapotranspiration was modeled based on the monthly average potential evapotranspiration in inches for Portland, ME developed by the Northeast Regional Climate Center. The May value (3.09 inches) was used for the steady-state model.
- The Analytical Well package was used to simulate the production wells. As it was unclear exactly which well points were in operation in October 2019 during the field reconnaissance completed by the consultant for this study, nor is the precise location of the well points monitored by Timson in 1990 known, withdrawals were modeled from a single well point at the center of the well point area. The analytical well withdraws water from Layer 3 of the model.
- The Constant Head cells were set based on the present mean sea level as derived from the tide data for Portland, ME[1]. Based on observed tide data during field work on October 25, 2019 in comparison to recorded tidal data at Portland, ME, the range of tides at the tide station appeared reasonable for calculation of mean sea level (-0.32 feet NAVD88) at Swim Beach for the steady-state model. This value was used to represent existing (and 1990-era) conditions.

2.2.5 Aquifer Parameters

Selection of aquifer parameters was generally guided by existing reports and available literature, although an informal calibration process for the model was performed based on the May 1990 pumping test. Initial parameters were assigned as presented in Table 2-1.

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[1] https://tidesandcurrents.noaa.gov/datums.html?datum=NAVD88&units=0&epoch=0&id=8418150&name=Portland&state=ME

TABLE 2-1
Hydrogeologic Setting

Parameter	Initial Value	Source	Final Value
Hydraulic Conductivity (Peat)	2.5 ft/d H, 0.25 ft/d V	Wong (2009)[2]	5.0 ft/d H, 0.2 ft/d V
Hydraulic Conductivity (Clay)	0.01 ft/d H, 0.001 ft/d V	Assigned	0.01 ft/d H, 0.005 ft/d V
Hydraulic Conductivity (Sand)	7.6 ft/d H, 0.76 ft/d V	Timson (1991)	17 ft/d H, 0.76 ft/d V
Hydraulic Conductivity (Shoreline)	1.0 ft/d H, 0.1 ft/d V	Assigned	0.75 ft/d H, 0.1 ft/d V
Streambed Hydraulic Conductivity	2.0 ft/d or 0.2 ft/d	Assigned	2.0 ft/d or 0.2 ft/d
Specific Yield (Peat)	0.44	Johnson (1967)[3]	0.44
Specific Yield (Shoreline)	0.27	Johnson (1967)	0.27
Specific Storage (Clay)	5.85×10^{-4}	Domenico (1965)[4]	5.85×10^{-4}
Specific Storage (Sand)	2.30×10^{-5}	Domenico (1965)	3.0×10^{-4}
Specific Storage (Shoreline)	5.05×10^{-5}	Domenico (1965)	5.05×10^{-5}
Porosity (Peat)	0.85	Wong (2009)	0.85
Porosity (Clay)	0.46	Morris (1967)[5]	0.46
Porosity (Sand)	0.40	Morris (1967)	0.40
Porosity (Shoreline)	0.30	Morris (1967)	0.30
Recharge	0.0036 ft/d (40%)	Timson (1991)	0.0036 ft/d (40%)
Flux Across Boundaries	16%	Assigned	16%
Evapotranspiration (May)	0.0083 ft/d to 5 ft	NRCC	0.0083 ft/d to 5 ft

Hydraulic conductivity and storage zones were consistent with those identified by Timson (1991), namely freshwater peat, lake clay, coarse-grained glacio-marine gravelly sand, and coarse-grained beach and washover deposits on the shoreline. As shown in Figure 2-2b (Figure 6 from the 1991 Timson report), Timson (1991) postulated that the freshwater / saltwater interface was close to the shoreline on the west side of Main Street. Model boundary conditions are depicted in Figure 2-1.

Targets were added to the model in order to perform an informal calibration. This report considers the calibration process to be informal because only a limited number of targets were available. Three targets were available in Timson (1991) for pre-test heads taken on the afternoon of May 29, 1990. These included the pumping well point and two other well points located approximately 25 feet and approximately 50 feet southwest of the pumping well point. Note as that these heads were measured prior to the start of seasonal pumping, the steady-state model represents a non-pumping condition. The data was used to determine the difference in head between simulated and observed conditions in the steady-state model.

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[2] L.S. Wong, R. Hashim and F.H. Ali, 2009. A Review on Hydraulic Conductivity and Compressibility of Peat. Journal of Applied Sciences, 9: 3207-3218.

[3] Johnson, A.I. 1967. *Specific yield — compilation of specific yields for various materials*. U.S. Geological Survey Water Supply Paper 1662-D. 74 p.

[4] Domenico, P.A. and M.D. Mifflin, 1965. Water from low-permeability sediments and land subsidence, Water Resources Research, vol. 1, no. 4., pp. 563-576.

[5] Morris, D.A. and A.I. Johnson, 1967. Summary of hydrologic and physical properties of rock and soil materials as analyzed by the Hydrologic Laboratory of the U.S. Geological Survey, U.S. Geological Survey Water-Supply Paper 1839-D, 42p.

Drawdown data from the approximately 15-hour pumping test was available for the two non-pumping well points. The pumping well was operated at an average rate of 5 gallons per minute during the May 1990 pumping test. The data was used to determine the difference in drawdown between simulated and observed conditions in the transient model. The pumping test data is included in the Timson (1991) report in Appendix B.

2.2.6 Model Sensitivity Analysis

In order to perform the informal calibration, automatic sensitivity analyses within Groundwater Vistas were used to refine starting model parameters during the development of the model. Adjusted parameters included recharge, evapotranspiration rate, horizontal and vertical hydraulic conductivity, storage properties, boundary flux, streambed conductivity. Parameters were adjusted from 50% to 150% of the starting value during each iterative simulation, which included both steady-state and transient model runs. The model was particularly sensitive to changes to hydraulic conductivity and specific storage in the glaciomarine sand. Some adjusted parameters resulted in dry cells and/or unstable simulations. In general, unrealistic adjustments to parameters following each iterative simulation were not permitted even if the residual sum of squares would be improved. This ensured that the model parameters would each remain within a reasonable range expected from previous investigations and related literature.

Refer to Figure 2-3 for the graphed results following the final sensitivity iteration. The resultant sum of squares for the residuals was 1.1 at the final iteration. Further iterations would not have had a measurable benefit.

Figure 2-3

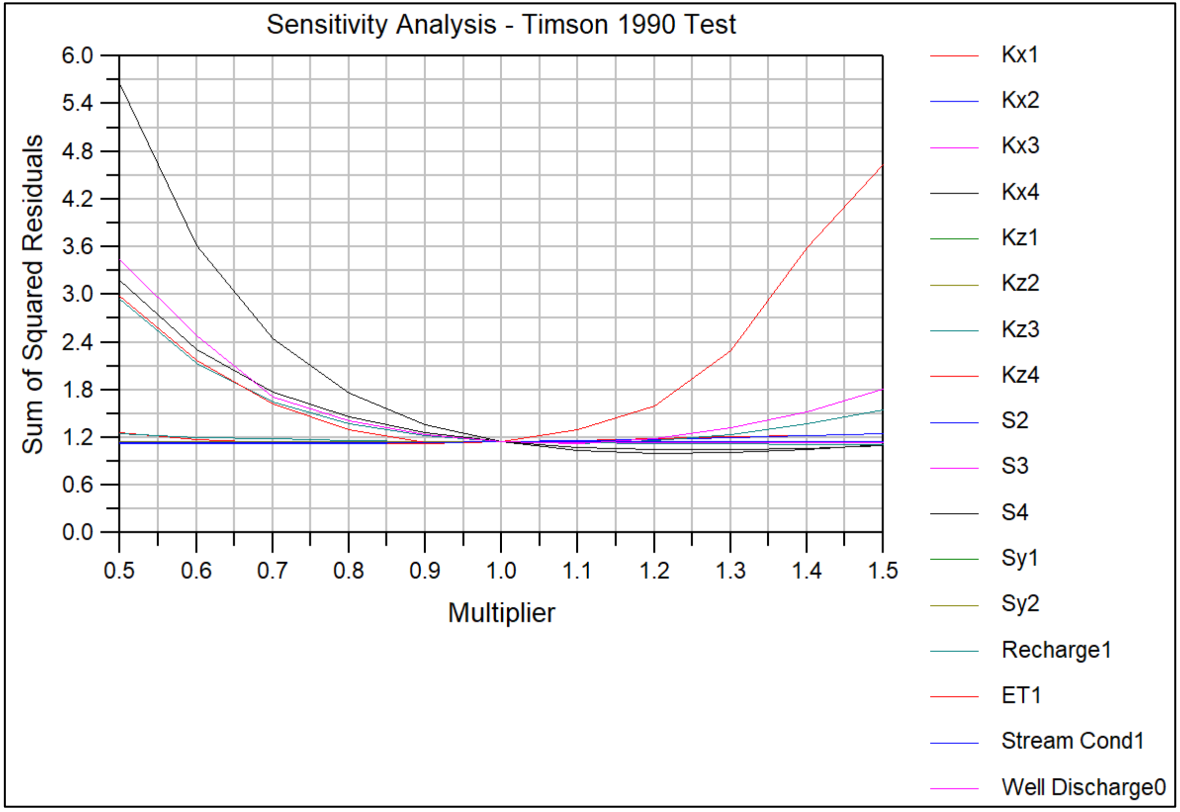

Table 2-2 presents a comparison between the observed and simulated water levels prior to the 1990 test. Water levels were simulated slightly lower than observed which is a conservative condition. The average residual was approximately one-tenth of a foot. The resulting heads are presented on Figure 2-4 and appear realistic for the Meadow aquifer.

TABLE 2-2
Measured and Simulated Heads on May 29, 1990 Prior to Pumping Test

Name	Model Layer	Observed Water Elevation (ft)	Simulated Water Elevation (ft)	Residual (ft)
Timson Well #1	3	10.13	10.09	0.04
Timson Well #2	3	10.19	10.07	0.12
Timson Well #3	3	10.21	10.11	0.10

Table 2-3 presents a comparison between the observed and simulated drawdowns during the 1990 test. The absolute value of all residuals were less than 0.5 feet. The simulated drawdowns at the end of the pumping test are presented on Figure 2-5.

TABLE 2-3
Measured and Simulated Drawdowns During May 29-30, 1990 Pumping Test

Name	Elapsed Time (hr)	Observed Drawdown(ft)	Simulated Drawdown (ft)	Residual (ft)
Timson Well #2	3	0.80	0.60	0.20
	6	0.85	0.82	0.03
	9	0.85	0.95	-0.10
	12	0.85	1.06	-0.21
	End	0.85	1.19	-0.34
Timson Well #3	3	0.65	0.35	0.30
	6	0.74	0.53	0.21
	9	0.78	0.66	0.12
	12	0.81	0.76	0.05
	End	0.82	0.89	-0.07

Figure 2-6 presents the hydrographs of the measured and simulated drawdown data. The relatively stable drawdown condition observed by Timson (1991) suggests that the cone of depression reached a recharge boundary during the 15-hour pumping test. The recharge boundary was likely either the overlying leaky clay confining layer or a lateral recharge boundary. Recall that Layers 2 and 3 were simulated using confined layers. This is common practice in order to encourage model convergence, particularly in models where limited data is available. The continued drawdown condition is typical of a transient confined model layer.

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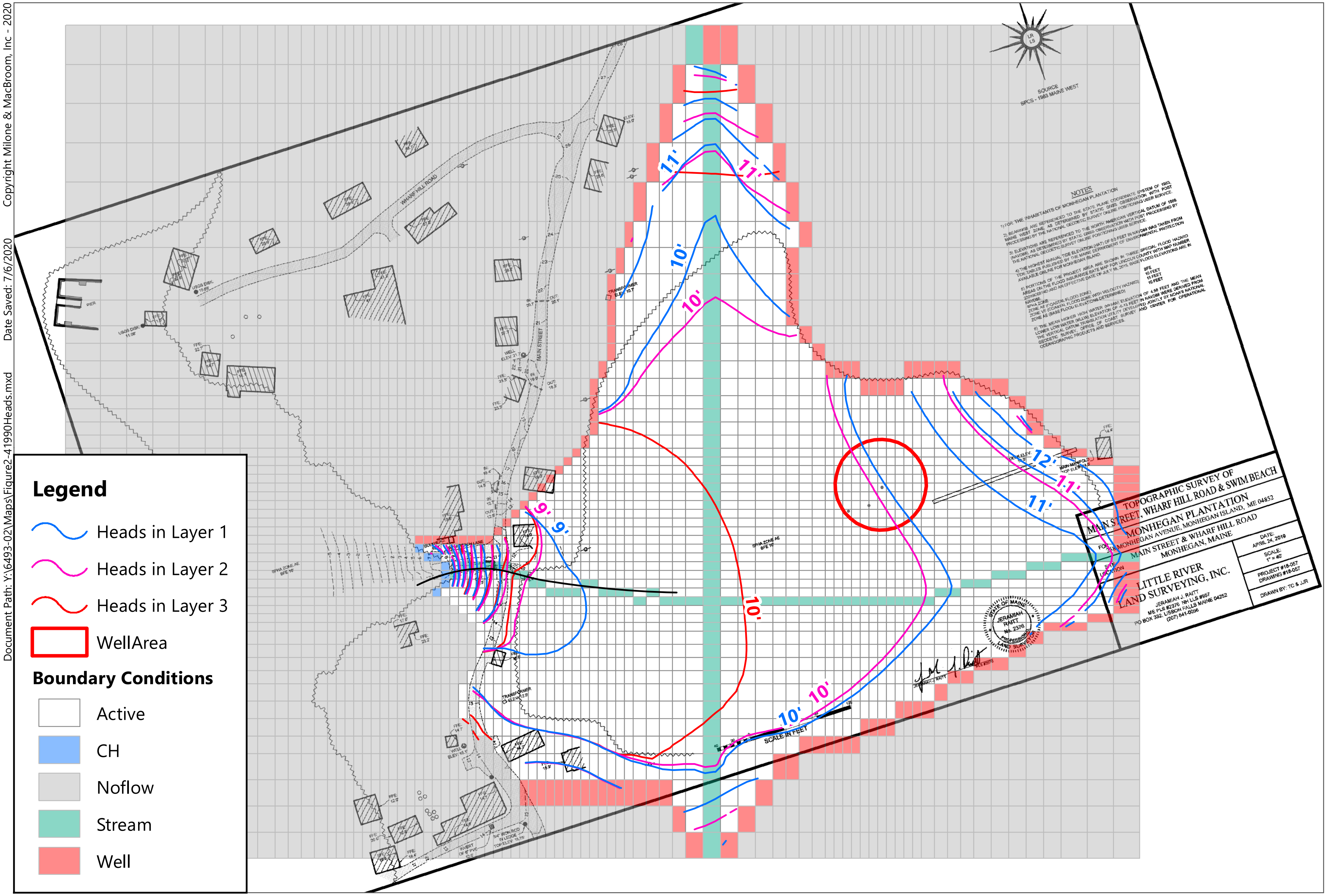

FIGURE 2-4: MODELED HEADS ON MAY 29, 1990

ALTERNATIVE WATER SUPPLY FEASIBILITY STUDY
TOWN OF MONHEGAN PLANTATION, ME

0 75 150
Feet
1 in = 150 feet

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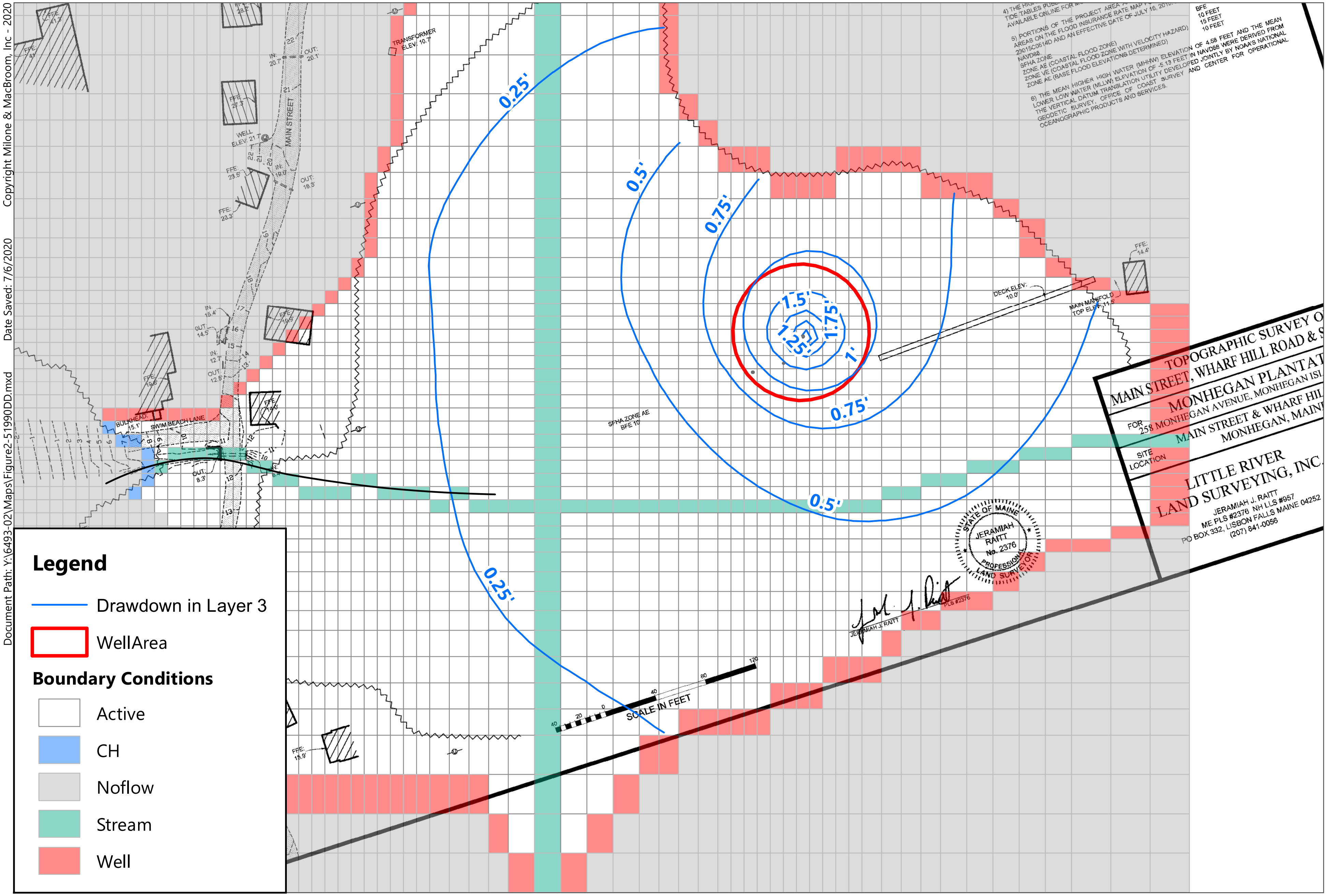

FIGURE 2-5: MODELED DRAWDOWN ON MAY 30, 1990

ALTERNATIVE WATER SUPPLY FEASIBILITY STUDY
TOWN OF MONHEGAN PLANTATION, ME

0 50 100
Feet
1 in = 100 feet

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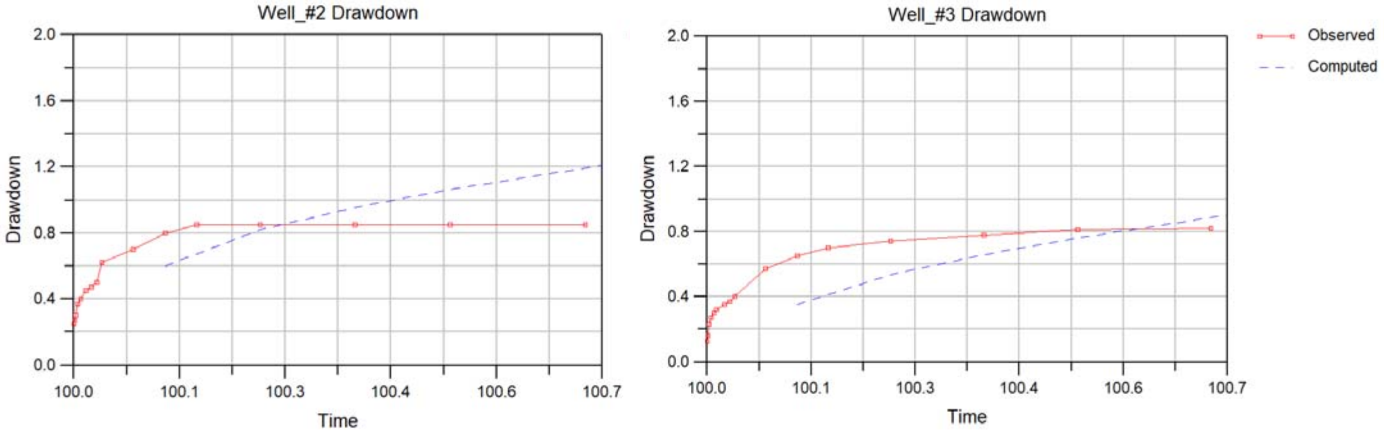
Figure 2-6
Observed vs. Simulated Water Level Data, May 1990 Pumping Test



During the limited field work conducted by the consultant on October 25, 2019, one of the well points was pumped at 5 gpm for several hours while water levels were monitored in nearby well points and at the Meadow surface. The difference in head measured between the Meadow surface and the well points installed in the glaciomarine sand at the bottom of the Meadow aquifer ranged from 0.18 feet to 1.59 feet, with the greater difference located closer to the pumping well. The 1990 pumping test simulation resulted in heads of approximately 10.0 feet in Layer 1 and 7.7 feet in Layer 3 at the pumping well after 15 hours of pumping. The 2.3-foot difference in head between the two model layers is comparable to that observed during the October 2019 field work, particularly given the October pumping period was only a few hours long.

Furthermore, water levels in the Meadow were modeled sufficiently high that minimal water flow is flowing through the Main Street culvert, which is typical for late May. Thus, the model was considered to have simulated the Timson 1990 pumping test appropriately given the limited data available.

2.3 Annual Model

An "annual model" of the Monhegan Aquifer was developed to evaluate how conditions change over a typical year. The model uses the non-pumping steady-state simulation from the Timson pumping test (May 1990) as the first stress period. A total of 12 transient stress periods were added to represent typical conditions in Monhegan, ME in June through May. Recharge and evapotranspiration were set for each month based on long-term monthly averages[6][7]. The model was run first with no withdrawals from the wellfield, and then run a second time with a constant 5 gpm withdrawal for the months of June through October.

Figure 2-7 presents the simulated drawdown for the October condition after 5 months of pumping at a constant rate of 5 gpm.

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[6] https://weather.com/weather/monthly/l/Monhegan+ME?canonicalCityId=7dbeca2f38e92e1e6767db175171cb77870dfb63dc2b4831bd1c9ffe08309613

[7] http://www.nrcc.cornell.edu/wxstation/pet/pet.html

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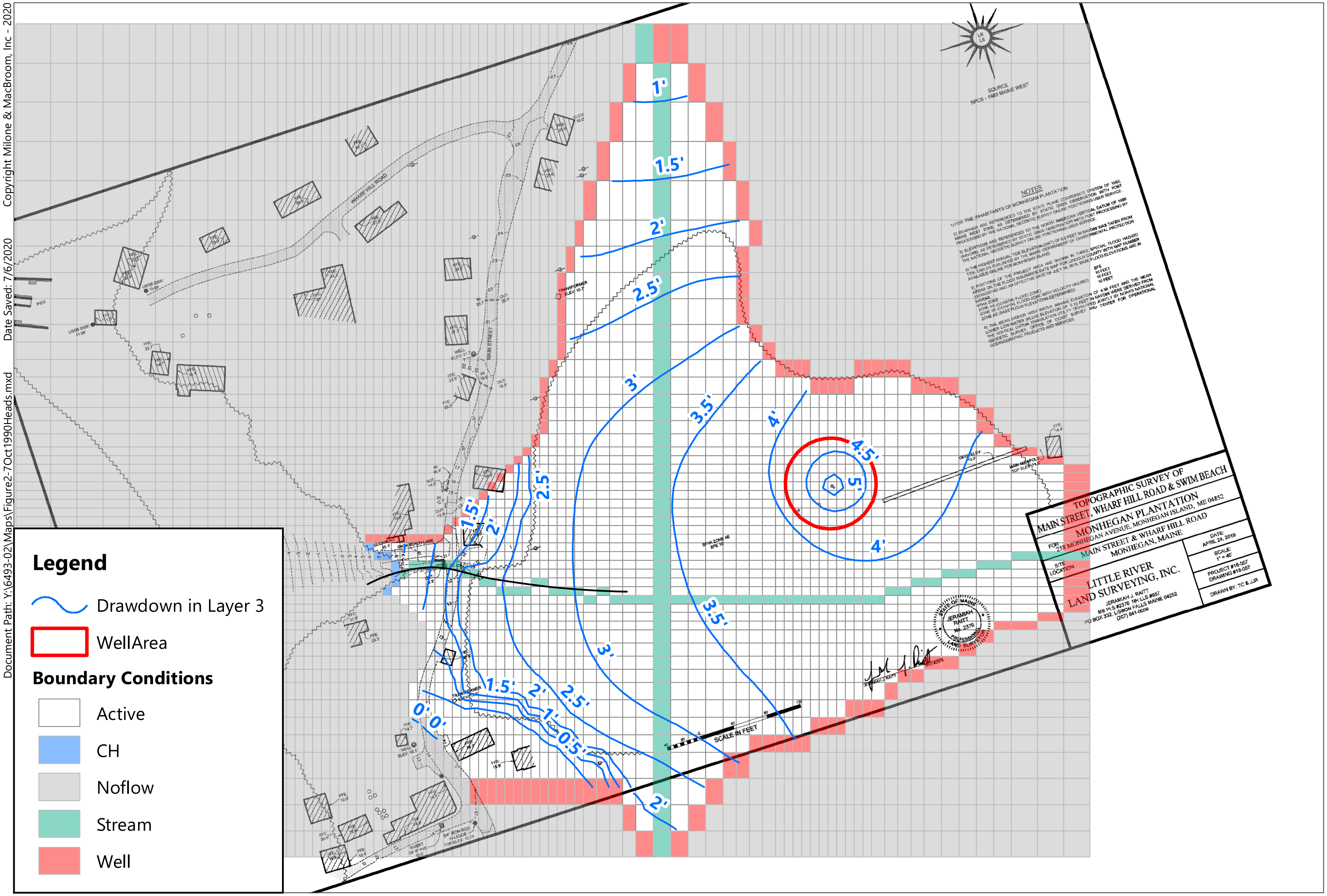

FIGURE 2-7: MODELED OCTOBER DRAWDOWN

ALTERNATIVE WATER SUPPLY FEASIBILITY STUDY
TOWN OF MONHEGAN PLANTATION, ME

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The simulated drawdown in Layer 3 is approximately 6 feet. The model does not simulate any drawdown remaining at the end of the simulated period (end of May following an off-season of no pumping). In fact, simulated heads are approximately six inches higher than at the end of the steady-state model, suggesting that the withdrawal is not dewatering the aquifer under average annual conditions.

2.4 Predictive Simulations

Steady-state predictive simulations were performed to delineate the area of contribution to the Monhegan Wellfield and determine how the boundary of that area may be affected by sea level rise. The 1990 steady-state model was used as the basis for the predictions. Adjustments were made to the constant head boundary cells to evaluate sea level rise under the following scenarios:

- 2020 Model: Sea level remained at -0.32 feet NAVD88
- 2050 Model: Sea level set at 0.68 feet NAVD88 (+1 foot of rise from present conditions)
- 2080 Model: Sea level set at 2.68 feet NAVD88 (+3 feet of rise from present conditions)

Starting heads were determined for each scenario by running the model under a non-pumping condition with an initial head of 40 feet in each model layer. The resultant heads were used as the starting heads for the predictive scenarios with the wellfield pumping at 5 gpm.

Forward particle tracking in MODPATH was used to delineate the area of contribution to the wellfield under the three scenarios. Particles were added to each model cell in Layer 3. The particle tracking revealed that the majority of model cells in Layer 3 track to the pumping well under the steady-state condition. The remaining model cells track to the ocean (the constant head boundaries).

Figure 2-8 presents the results of the particle tracking for the three scenarios. The simulations indicate that as sea level rises, the area of contribution to the wellfield will move slightly more seaward than under present conditions even though the pumping rate does not change. Note that as the boundary of the area of contribution moves seaward it will approach the freshwater-saltwater interface in the aquifer. Timson 1991 concluded that this interface lay seaward of Main Street.

2.5 Conclusions from Aquifer Model

While more detailed modeling would be necessary to conclude exactly why the area of contribution will move seaward with sea level rise, it is likely that the higher sea level will reduce the existing gradient between the head in the Meadow aquifer and the head in the ocean. At present, heads decline relatively steeply from approximately 9 feet NAVD near Main Street to approximately 0 feet NAVD at the ocean at Swim Beach. The rising sea level will decrease that gradient. The simulations suggest that groundwater near the weakened gradient therefore becomes more susceptible to being drawn towards the wellfield when it is pumping rather than being drawn down the gradient to the ocean.

As the area of contribution moves seaward, there will be more of a chance that brackish water will be drawn towards the wellfield as the area of contribution to the wellfield will be closer to the freshwater-saltwater interface. However, even with the predicted three feet of sea level rise, the modeled area of contribution remains predominantly under the meadow and the simulation largely does not draw particles from cells west of Main Street, making it unlikely that the area of contribution will include brackish water.

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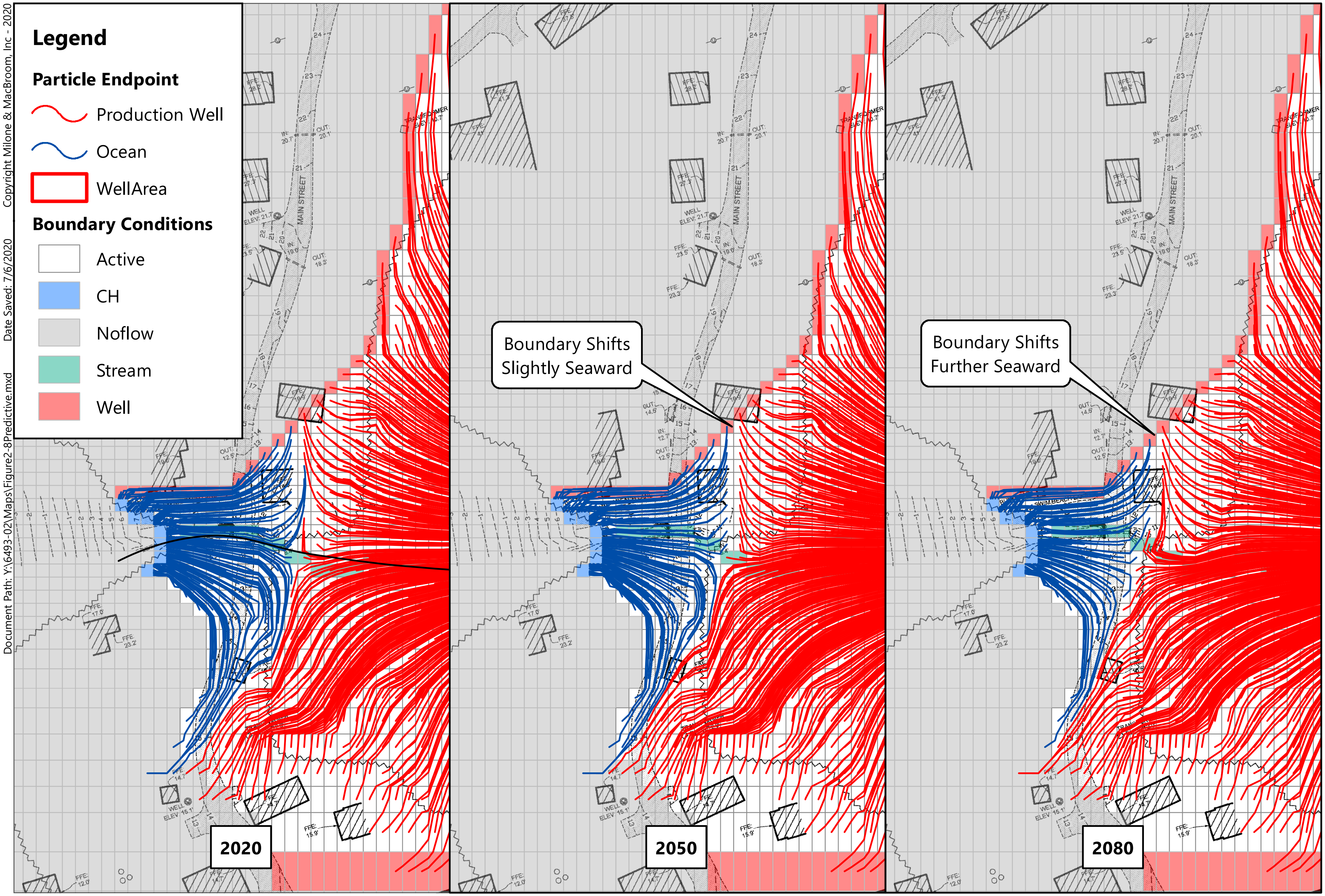

Boundary Shifts Slightly Seaward

Boundary Shifts Further Seaward

FIGURE 2-8: PREDICTIVE MODELING

ALTERNATIVE WATER SUPPLY FEASIBILITY STUDY
TOWN OF MONHEGAN PLANTATION, ME

0 50 100
Feet
1 in = 100 feet

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Furthermore, the predictive models demonstrate that as sea level rises, the head in Layer 3 is also slightly increasing (e.g., the head increases approximately 0.4 feet between the 2050 and 2080 scenarios). The slightly increased head will help to mitigate the gradient loss and ensure that freshwater heads are greater than mean sea level. Therefore, the limited (but conservative) modeling suggests that 1 to 3 feet of sea level rise does not have a more than low potential for saltwater intrusion at this time, assuming that aquifer usage remains seasonal and relatively constant over the coming years.

Based on the Ghyben-Herzberg principle (discussed in more detail in Sections 3.4.1 and Sections 3.5.3), the estimated depth of the freshwater- saltwater interface is very deep below the Meadow Aquifer. The information in the Timson (1991) report suggests that the deepest depth of the Meadow Aquifer is approximately 100 feet below sea level, while the Ghyben-Herzberg principle suggests that the interface is presently in the bedrock aquifer approximately 360 to 440 feet below current mean sea level. As sea level rises through 2080, the interface is expected to continue to remain below the bottom of the aquifer at approximately 240 to 320 feet below the current mean sea level. However, at this time it is unclear how this potential change in the vertical freshwater-saltwater interface elevation will affect freshwater bedrock fractures that may feed the lower reaches of the Meadow Aquifer.

Should new sea level rise scenarios be developed in the future that exceed three feet over present conditions, it is recommended that more in-depth modeling be conducted to evaluate the potential for saltwater intrusion. Such a risk assessment should include a long-term pumping test with monitoring of water levels at many locations, borings to determine if overburden groundwater is present to the southwest of Main Street near Square House, and the use of SEAWAT or another predictive model that can more precisely determine the movement of the freshwater-saltwater interface.

3.0 BEDROCK AQUIFER CHARACTERIZATION AND RISK ASSESSMENT

3.1 Introduction:

As noted in Section 1.0, the Monhegan Water Company supplies water seasonally to many of the island residents and businesses. During the off-season, the water system is shut down and water is supplied through a series of privately-owned drilled wells. Monhegan Island has not experienced significant issues with salt-water intrusion in its private water supply wells. Nevertheless, the island's residents and leadership are aware that changing climactic conditions and summer demands on the water system put the island at risk for this to occur.

An environmental scientist recorded measurements of various private wells, a potential municipal well, and in the waters of the meadow aquifer on October 26, 27, and 28, 2019. Figure 3-1 shows the locations of the wells that were viewed and characterized. The compilation of this information can then be used to detect evidence of current salt-water intrusion, as well as advise the best course of water management under future conditions.

3.2 Background

Saltwater intrusion can be described as a phenomenon wherein a freshwater aquifer is contaminated with compounds from salt water to the detriment of the aquifer's water quality. This most often occurs when the hydraulic head of the freshwater aquifer is insufficient to inhibit the denser saltwater from forcing its way into the formation containing the fresh water supply. It can also occur when there is direct inundation of a source water area due to flooding from storm surge or other phenomena. In either case, the water supply becomes contaminated with various dissolved ions with consequences ranging from foul taste to complete loss of untreated water potability.

In the case of Monhegan island, there are two formations which can experience saltwater intrusion. The bedrock aquifer comprises nearly the entire island and contains fractures, which become narrow reservoirs for fresh water. The freshwater is sourced from the island's rainfall, which averages roughly 48 inches per year. Water is withdrawn from the bedrock aquifer by drilling a well and intersecting the fracture planes, causing the water to spill into the well casing. The second aquifer is known as the Meadow Aquifer; a small bowl-shaped depression in the bedrock filled with medium grained glaciomarine sands, which uses the pore space between the sand grains as its storage reservoirs. To withdraw water from this aquifer, shallow well points are used to induce a cone of depression and draw water from the void spaces between sand grains. The Meadow Aquifer does not exist in isolation from the bedrock aquifer. It is likely that a large portion of the Meadow's recharge comes from interactions with the bedrock fractures under the surface. Thus, the Meadow Aquifer is potentially vulnerable to saltwater intrusion indirectly from fracture intrusion and directly from salt-water inundation.

Salt-water intrusion is a concern for the residents of Monhegan Island, due to the islands small size and its reliance on The Meadow as its primary water source for the municipal water company. This aquifer is separated from the high-water mark at Swim Beach by just over 100 feet, with less than four feet in elevation required for Monhegan Harbor's waters to flood the culvert under the Main Street right of way and spill into the Meadow. This narrow barrier has the potential to be overtopped with increasing frequency as sea level rise and stronger ocean storms affect the area. While the glaciomarine sands are separated from the surface of the meadow by a layer of relatively impermeable peat, prolonged or repeated inundation of The Meadow by seawater has the potential to introduce various salt-water constituents into the water supply, which can threaten human health. Saltwater intrusion is also a threat to the islands many bedrock wells, which are used to supply many homes and businesses.

Figure 3-1: Observed Wells

Alternate Water Supply Feasibility Study
Monhegan, Maine

0 0.05 0.1
MILES

1 in = 350 ft

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3.3 Current Water System and Reason for Private Well Use

Water from the Monhegan Water Company public water system is pumped from the Meadow aquifer through a series of shallow well points, which are connected through manifolds to a vacuum pump. Water is then pumped up to twin storage tanks adjacent to the lighthouse and distributed through a surface-level distribution system. Since the well point connections, manifolds, pumps, and distribution system are all at or near the surface, the system must be shut down overwinter to prevent damage from freezing. When the water system is shut down, typically in late October, the only source of potable water on the island comes from bedrock wells. Numerous bedrock wells have been drilled on the island at private residences and businesses. These wells are typically in the range of 200-400 feet deep, and are relatively low yielding, with some exceptions. Basement storage cisterns provide additional, non-potable water to properties.

3.4 Methodology

3.4.1 Conceptual Interface Position

In order to understand the risk of salt-water intrusion, it is essential to understand how freshwater and salt water interact in an isolated island environment. The bedrock freshwater on the island can be thought of as a lens shaped formation, with a rounded protrusion of water above sea level, and a significantly deeper semi-circular shaped interface below sea level. This shape is modeled by the Ghyben-Herzberg principle, z= (Qw/(Qs-Qw) * h where z is the depth of the interface below seas level, h is the elevation of the fresh water table above sea level, Qw is the density of freshwater, and Qs is the density of saltwater (Tuttle, S. 2007) Put simply, the depth of the interface below sea level is approximately 40x the elevation of the water table above sea level. It is important to note that this principal is idealized and typically found in unconsolidated material aquifers. The complexity of the bedrock geology on Monhegan Island complicates the variables, lending only limited credence to the formula. This formula was not applied to the shallow dug wells on the island, because it is not clear whether there is an unsaturated bedrock zone between the overburden water table and the bedrock water table. However, it is a fitting acceptable baseline for analyzing well risk at this time.

The consequence of the interface geometry transcends the assessment of risk by lateral well location alone. The depth of the well bore is critical, as it is possible to drill through the freshwater aquifer formation and expose the water column to intrusion from below the freshwater lens. This is especially relevant to Monhegan Island, where some of the low-producing wells are drilled with their bottom elevations several hundred feet below sea level. Each bedrock well will be analyzed as the potential for this risk in the coming sections.

3.4.2 Chemical and Physical Properties Methodology

When possible, water from the meadow aquifer, bedrock wells, and some shallow dug wells were analyzed with a YSI650MDS meter which read out several parameters including temperature, conductance (temperature corrected conductivity), salinity, as well as a range of other parameters not specifically pertinent to the analysis of saltwater intrusion. Each well that could be accessed was also measured for depth to water using a Heron Dipper-T water level meter. Samples were gathered from select wells and provided to a Maine-certified testing laboratory for chloride and total dissolved solids sampling. When possible, the lab samples were gathered upstream of the pressure tank and any treatment devices in order to provide the most reflective sample of groundwater conditions.

In all, 20 sites were accessed. A total of 16 sites were bedrock wells, whereas three sites were shallow dug wells, and the remaining site was the meadow aquifer itself. Not every well could be assessed for every parameter. For example, some wellheads were inaccessible, so depth to water measurements could not be taken, however there was access to a sample tap inside the house. Other wells had accessible wellheads, but the water system was shut off inside the seasonal residence that it served. The results of the sampling are summarized in appended Table .1

3.4.3 Comparisons with Drinking Water Standards and other Benchmarks

The results of the testing and sampling were compared to national and state drinking water standards, when applicable, and to other benchmarks of water quality when no specific drinking water standards exist. Both chloride and total dissolved solids (TDS) fall under the EPAs secondary water standards. This means that testing for these substances is done on a voluntary basis, and there is no enforcement action for elevated results. Nonetheless, there can be health and water quality concerns with elevated levels of these substances. In the case of Monhegan Island's water supplies, elevated chloride and TDS levels could implicate salt-water intrusion as a cause. The following list summarizes the drinking water standards applicable to this testing. The results are further summarized in the table below.

- The secondary EPA standard for chloride is 250 mg/L,
- The secondary EPA standard for TDS is 500 mg/L.
- There is no standard for conductivity, but as a point of reference, normal surface fresh water is ordinarily between 50-1000 us/cm. The readout cited in this report for conductivity is the specific conductance, which is the conductivity temperature corrected to a standard of 25 degrees Celsius.
- Salinity was read from the YSI 650MDS readout. This is derived from the conductivity measurement and is of limited value in determining salt-water intrusion risk as a standalone figure because it does not specify the ionic composition. There are no explicit drinking water standards for salinity, however as an easy point of comparison, NOAA considers a body of water "fresh-water" for the purposes of biological habitability when salinity is below 0.5 parts per thousand (ppt). Each monitoring point is described below, along with the information gathered at each location.

Parameter	EPA Standard	Reference Standard
Chloride	250 mg/L	N/A
Total Dissolved Solids (TDS)	500 mg/L	N/A
Conductivity	N/A	50-1000 us/cm
Salinity	N/A	0.5 parts per thousand

3.5 Well Monitoring Results

Results of the analysis described below are summarized in Appended Table 1.

3.5.1 Bedrock Wells

MISCA Well: The MISCA well is one of the newest wells on the island, drilled in the last few years. The well is located just to the northeast of the meadow aquifer on the hill leading up to the lighthouse. The approximate elevation of the wellhead is 34 feet above MSL. The well has a standard 6-inch casing and is drilled to 260 feet. The casing protrudes approximately 16 inches from the ground surface, and the well pumps at roughly four to six gallons per minute. The well depth to water was 20.18 feet, which reflected a static level. The chloride level was 28 ppm, while the TDS level was 150 ppm. These values are both below EPA secondary standards. The conductance was 197 us/cm, with a salinity of 0.09 ppt. These are both within the normal freshwater benchmarks indicated previously.

Using the simplified Ghyben-Herzberg principal, the freshwater lens is estimated to extend to an elevation 606 feet below sea level at the location of the MISCA well. This indicates that the well's bottom of boring is expected to lie within the freshwater lens.

Lord, V: This drilled well serves the private Lord residence, and is located 75 feet from the Island Inn, and 300 feet from the coastline. It is at an approximate elevation of 31 feet, and the observed depth to water was 22.35 feet, with a casing height of 12 inches. The well did not appear to be in use at the time, so the measured depth to water is assumed to be reflective of a static level. The chloride level was 64 ppm, while the TDS level was 390 ppm. These values are both below EPA secondary standards. The conductance was 503 us/cm, with a salinity of 0.24 ppt. These are both within the normal freshwater benchmarks indicated previously.

Using the simplified Ghyben-Herzberg principal, the freshwater lens is estimated to extend approximately 386 feet below sea level at the location of the Lord well. Although the well's bottom of boring is not known, no other wells observed in the area exceeded 380 feet, making it likely that this well is drilled entirely within the freshwater lens.

Store Well: This is a drilled well which serves the L. Bracket and Sons general store as well as an adjacent private residence. The wellhead is located just to the west of the meadow aquifer and is approximately 475 feet from the shoreline. The condition of the wellhead precluded depth to water measurements, but an accessible sample tap within the building allowed for the YSI 650MDS parameters to be sampled. The conductance was 338 us/cm, with a salinity of 0.16 ppt. These are both within the normal freshwater benchmarks indicated previously.

Lisa's Well: Lisa's well serves a private residence adjacent to the shoreline. This drilled well is set back to the east, approximately 400 feet from shore and close to Main Street. At the time of the visit, the wellhead was covered in an insulation type material, and thus was not disturbed. There was an accessible sample tap in the house however, so the remaining YSI 650MDS and laboratory readings were gathered at this well. The chloride level was 56 ppm, while the TDS level was 380 ppm. These values are both below EPA secondary standards. The conductance was 502 us/cm, with a salinity of 0.27 ppt. These are both within the normal freshwater benchmarks indicated previously.

Square House: This drilled well serves a private residence and is located approximately 245 feet north of Lisa's well along the shoreline. The well is bored to a depth of 210 feet deep. It is at an approximate elevation of 14 feet, and the observed depth to water was 6.48 feet, with a casing height of 16 inches. The well did not appear to be in use at the time, so the measured depth to water is assumed to be reflective of a static level. The chloride level was 60 ppm, while the TDS level was 430 ppm. These values are both below EPA secondary standards. The conductance was 558 us/cm, with a salinity of 0.27 ppt. These are both within the normal freshwater benchmarks indicated previously.

Using the simplified Ghyben-Herzberg principal, the freshwater lens is estimated to extend approximately 354 feet below sea level at the location of the Square House well. This indicates that the well's bottom of boring is expected to lie within the freshwater lens.

Norma's Well: The drilled well serving Norma's private residence is approximately 1,000 feet southwest of the Meadow and 330 feet from the shore. The well is 297 feet deep, with a measured depth to water of 15.51 feet. The house was unoccupied at the time of the reading, so this depth to water is assumed to reflect static level. The elevation of the well is approximately 35 feet above MSL, and the casing protrudes roughly 11" above ground level. The chloride level was 82 ppm, while the TDS level was 460 ppm. These values are both below EPA secondary standards. The conductance was 593 us/cm, with a salinity of 0.29 ppt. These are both within the normal freshwater benchmarks indicated previously.

Using the simplified Ghyben-Herzberg principal, the freshwater lens is estimated to extend approximately 856 feet below sea level at the location of Norma's well. This indicates that the well's bottom of boring is expected to lie within the freshwater lens.

Matt's Well/Brewing Company Well: Matt's well serves both his private residence and the Monhegan Island Brewing Company. This was the most southerly well accessed, located approximately 2,200 feet south of the meadow aquifer and 1,000 feet east of the shoreline. The elevation of the well is approximately 81 feet above MSL. This well is 280 feet deep, with a measured depth to water of 5.66 feet. Although Matt was home at the time of the visit, the extremely shallow depth to water suggests that the well was at or near static level when the measurement took place. The elevation of the well is approximately 81 feet above MSL, and the casing protrudes 13 inches from ground surface. The chloride level was 84 ppm, while the TDS level was 370 ppm. These values are both below EPA secondary standards. The conductance was 485 us/cm, with a salinity of 0.24 ppt. These are both within the normal freshwater benchmarks indicated previously.

Using the simplified Ghyben-Herzberg principal, the freshwater lens is estimated to extend approximately 3,057 feet below sea level at the location of Matt's Well/Brewing Company well. This indicates that the well's bottom of boring is expected to lie within the freshwater lens.

Black Duck Well: The Black Duck well serves a small business in the center of the village. The well is approximately 300 feet southwest of the meadow aquifer and 350 feet from the shoreline. The wellhead itself is located in the basement of the building at an elevation of approximately 20 feet above MSL. The split cap-style well rises approximately 3 inches from the floor and was accessible to the water level meter through a small vent hole. The depth to water was 6.18 feet, which is assumed to be static level since the business was closed for the season. Since the water system had been turned off, it was not possible to obtain a sample from the tap at the time of the visit.

Using the simplified Ghyben-Herzberg principal, the freshwater lens is estimated to extend approximately 562 feet below sea level at the location of the Black Duck well. Although the well's bottom of boring is not known, no other wells observed in the area exceeded 380 feet, making it likely that this well is drilled entirely within the freshwater lens.

Lighthouse Hill Well: The Lighthouse Hill Well served a private residence approximately 150 feet northeast of the lighthouse. This well is at an approximate elevation of 127 feet above MSL, the highest well observed. The depth to water was 13.44 feet with a casing height of 11 inches. Since the owners were not present and the water system was shut off, this measurement was assumed to be reflective of the static water level. This also meant that no sample could be procured from the water system.

Using the simplified Ghyben-Herzberg principal, the freshwater lens is estimated to extend approximately 4579 feet below sea level at the location of the Lighthouse Hill well. Although the well's bottom of boring is not known, no other wells observed in the area exceeded 380 feet, making it likely that this well is drilled entirely within the freshwater lens.

Jenney Cottage: The Jenney Cottage well serves a private residence approximately 500 feet northwest of the meadow aquifer and 230 feet from the shoreline. This well is at an approximate elevation of 36 feet above MSL. The depth to water was 8.75 feet with a casing height of 16 inches. As with many of the other seasonal properties, the owners were not present and the water system was shut off. While this ensured that the depth to water measured was reflective of static, it also meant that samples were not gathered from the water system.

Using the simplified Ghyben-Herzberg principal, the freshwater lens is estimated to extend approximately 1,143 feet below sea level at the location of the Jenney well. Although the well's bottom of boring is not known, no other wells observed in the area exceeded 380 feet, making it likely that this well is drilled entirely within the freshwater lens.

Travis's Well: Travis's Well serves a private residence located approximately 700 feet southeast of the meadow aquifer and 1,900 feet east of the shoreline. The well is situated at approximately 82 feet in elevation with a casing that protrudes 30.5 inches above the ground surface. We believe the depth is 380 feet deep, based on the cap, although an error in stamping the cap appeared to show 880 feet. Since this value would be twice the depth of the nearest well observed on the island, we felt it was more likely that the number "3" was stamped incorrectly. The depth to water was measured at 121.4 feet deep. Travis was home during the visit, and it is suspected that his water use may have caused the exceptional drawdown noted in this well. Other wells in the area did not exhibit such markedly low water level elevations, indicating that the static level of Travis's well is likely much higher that the observed level. Due to the low yield of the well (1 gpm according to the well cap), it is likely that any significant water use (washing clothes, showering, etc.) likely draws heavily from the storage in the wellbore. A water sample was not procured from this well for laboratory analysis and YSI 650MDS measurements were not taken.

The freshwater lens was not estimated at this well because the apparent usage during the test made it impossible to estimate the static level. Nearby wells indicated that the lens in the area was likely to be in the range of 2,500 to 3,000 feet below sea level.

Island Inn Well: The Island Inn Well serves its namesake structure and is located directly across the street from the meadow aquifer, and approximately 425 feet from the shoreline. The wellhead sits at approximately 22 feet in elevation, and the casing extends 5.75 inches above the ground. This well likely has the largest demand of any well on the island, as it is used in the summer for most potable needs at the inn. During the off-season it is used sparingly as a potable water source. The measured depth to water in the well was 9.2 feet, and the well depth is not known. The chloride level was 54 ppm, while the TDS level was 380 ppm. These values are both below EPA secondary standards. The conductance was 492 us/cm, with a salinity of 0.24 ppt. These are both within the normal freshwater benchmarks indicated previously.

Using the simplified Ghyben-Herzberg principal, the freshwater lens is estimated to extend approximately 532 feet below sea level at the location of the Island Inn well. Although the well's bottom of boring is not known, no other wells observed in the area exceeded 380 feet, making it likely that this well is drilled entirely within the freshwater lens.

Owner's House: The owners house well serves the private residence of the Island Inn owners. This well is located near the Plantation dock, approximately 215 feet from the shoreline. The well depth is not known, and the measured depth to water was 20.15 feet. The approximate elevation of the well is 22 feet above MS, with a casing that extends 19.75 feet above the ground surface. The chloride level was 64 ppm, while the TDS level was 420 ppm. These values are both below EPA secondary standards. The conductance was 492 us/cm, with a salinity of 0.24 ppt. These are both within the normal freshwater benchmarks indicated previously.

Using the simplified Ghyben-Herzberg principal, the freshwater lens is estimated to extend approximately 140 feet below sea level at the location of the Owner's House. The bottom of boring is not known in this well, although it is likely below the estimated interface which puts it at increased risk of saltwater intrusion. This result needs more study however, as the owners were home at the time of the visit. Thus, it is possible that the water level in the well did not reflect a static value.

Chris's House: The well serving Chris's House is located on the hill south of the Meadow, approximately 375 feet south of Travis's well. This well is 297 feet deep, with a depth to water of 16.36 feet. The elevation of the well is approximately 90 feet above MSL and the casing extends 14 inches from the ground surface. No water samples were gathered from this site.

Using the simplified Ghyben-Herzberg principal, the freshwater lens is estimated to extend approximately 2,992 feet below sea level at the location of Chris's well. This indicates that the well's bottom of boring is expected to lie within the freshwater lens.

Cameron Well: The Cameron well serves private residence 250 feet west of Chris's house. This well is 247 feet deep, with a depth to water of 5.74 feet. The elevation of the well is approximately 87 feet above MSL and the casing extends 10 inches from the ground surface. No water samples were gathered from this site.

Using the simplified Ghyben-Herzberg principal, the freshwater lens is estimated to extend approximately 3,284 feet below sea level at the location of Chris's well. This indicates that the well's bottom of boring is expected to lie within the freshwater lens.

3.5.2 Dug Wells

Becky's Well: This well is located 300 feet west of the Meadow, off of the road down to the dock. The well is covered by a newly constructed wooden cover and is constructed with stone masonry walls. The well depth is 14.84 feet, and the measured depth to water was 8.75 feet. The approximate elevation of the well is 36 feet above MSL, with an enclosure that extends 15 inches feet above the ground surface. While samples were not sent to the lab for analysis, YSI 650MDS readings were taken. The conductance was 446 us/cm, with a salinity of 0.22 ppt. These are both within the normal freshwater benchmarks indicated previously.

1784 House: This well is an inactive well located approximately 275 feet from the ocean shore. The well is covered by a wooden deck and is constructed with stone masonry walls. The well depth is 5.6 feet, and the measured depth to water was 2.9 feet. The approximate elevation of the well is 13 feet above MSL, with an enclosure that is flush with the ground surface. The chloride level was 32 ppm, while the TDS level was 410 ppm. These values are both below EPA secondary standards. The conductance was 531 us/cm, with a salinity of 0.26 ppt. These are both within the normal freshwater benchmarks indicated previously.

Hill Well: The Hill Well is an inactive dug well located under the deck of a private residence. Located 450 feet south of Matt's/Brewing Company Well, the well has a casing constructed of concrete and is approximately 3-4 feet in diameter. The casing extends 18 inches above the ground surface and is at an elevation of approximately 69 feet above MSL. The well depth is approximately 10 feet, and the measured depth to water was 2.4 feet.

3.5.3 Meadow Aquifer

Meadow Surface Water: Parts of the meadow are flooded with surface water with some regularity. This water was sampled to obtain information on the qualities of the island's surface water. The sample of surface water was analyzed with the YSI 650MDS meter. The conductance was 203 us/cm, with a salinity of 0.10 ppt. These are both within the normal freshwater benchmarks indicated previously.

Aquifer Ground Water: A sample was gathered from the Meadow aquifer groundwater, to determine if there was any evidence of saltwater intrusion in the water currently used to supply the island during the summer season. The chloride level was 44 ppm, while the TDS level was 400 ppm. These values are both below EPA secondary standards. The conductance was 525 us/cm, with a salinity of 0.26 ppt. These are both within the normal freshwater benchmarks indicated previously. Using the simplified Ghyben-Herzberg principle, the freshwater lens is estimated to extend approximately 376 feet below sea level in the Meadow Aquifer. This indicates that the meadow aquifer wellpoints are expected to lie within entirely within the freshwater lens.

The results are summarized in Appended Table 1

3.6 Conclusion:

After reviewing the results of the sampling from both the laboratory analytics and the YSI 650MDS readouts, none of the wells sampled nor the Meadow aquifer would be described as experiencing saltwater intrusion at the time of observation. While the bedrock wells did tend exhibit slightly higher chloride levels than the Meadow aquifer water, all of the chloride results were below the EPA recommended 250 mg/L and TDS was below 500 mg/L in all cases. In all cases, the conductivity and salinity were well within the normal freshwater range.

Of positive note is that the MISCA well, which is the furthest well from the shoreline that was sampled for all parameters, exhibited the lowest chloride, TDS, conductivity, and salinity of any of the wells sampled. While it would be useful to test this well during peak demand season, initial indications are that any saltwater influence is minimal at this location. This is encouraging, especially coupled with the relatively shallow depths to water in the wells at high elevations, such as the Lighthouse Hill Well and Chris's Well. With the water table extending approximately 113 feet above mean sea level in this location, it indicates that the freshwater lens rises rapidly from the shoreline and extends well above mean sea level, reducing the risk of saltwater intrusion.

Future testing should include more frequent water quality sampling, especially in wells that are pumped heavily. When wells are heavily used, the cone of depression widens, making it more likely that salt-water intrusion could occur. The following wells should be subject to further testing in order to better classify the water quality under a variety of climactic and pumping conditions:

- The Island Inn well would be an ideal candidate for additional sampling during the busy summer months. The test of that well during this visit occurred in the early off season, when the inn was closed and there was only minimal water use from the well.
- The Owner's House well and the Lord family well should be tested concurrently with the Island Inn well, since these wells are closest to the Island Inn well and also had the smallest theoretical buffer between the bottom of boring and the edge of the freshwater lens.

- Norma’s well exhibited one of the highest levels of chloride observed at 82 mg/L and the highest TDS level at 460 mg/L. While the chloride levels are still below the EPA secondary standard of 250 mg/L, the TDS was approaching the EPA secondary standard of 500 mg/L. This well would benefit from additional testing while the well was in use, to see if the pumping of the well induces saltwater intrusion.

While Monhegan Island’s water usage has experienced increases in recent years, the initial signs indicate that a viable bedrock aquifer exists on the island. With further sampling and study, it is possible that a series of bedrock wells could be drilled which could supplement, if not eventually replace the current municipal water system wells in the Meadow Aquifer. This would ease concerns about saltwater intrusion from inundation as well as reliability concerns that have existed regarding the aging system. Drilling inland bedrock wells could also allow for the operation of a year-round municipal water system, as it would no longer rely on surface water transmission mains which currently travel from the Meadow aquifer well points to the pump house. After winterizing the distribution system, the water company would be able to serve the island’s year-round population safely and effectively.

Monhegan Island is fortunate to have avoided some of the saltwater intrusion issues that have affected other local coastal areas. By proactively studying the island’s water resources and identifying the path forward, the island can ensure that its water supply remains safe and solvent in the future, despite the challenges of sea level rise and other environmental stressors.

4.0 BEDROCK WELL FEASIBILITY STUDY

4.1 Introduction

The Monhegan Water Company (Public Water System ID [PWSID] ME0091010) is considered a public water system because more than 25 people are served through more than 15 service connections. The Maine Drinking Water Program classifies the system as a Transient Non-Community (TNC) system because it serves at least 25 people, but not necessarily the same people, for at least 60 days per year; the system does not serve more than 25 people on an ongoing basis. In contrast, a Community Water System (CWS) is a public water system that supplies water to the same population year-round; and a Non-Transient Non-Community (NTNC) system regularly supplies water to at least 25 of the *same* people at least six months per year.

If the Monhegan Water Company determines that modifications or additions to the system sources are necessary, the Maine Drinking Water Program (DWP) requires an application and review process as articulated in the *Transient Public Water System Application for a New System or New Well*[8]. A copy can be found in Appendix C of this report. The application materials state that "If you are planning a new well for a new or existing Transient Public Water System, the materials you need for well and system approval are within this application or referred to in this application." The materials note that public water system wells must be at least 300 feet from septic leachfields and 1,000 feet from underground storage tanks.

The presence of viable private bedrock wells on Monhegan Island means that there is a high likelihood that the bedrock aquifer could support new sources for the public water system. Due to the island's small size and rugged topography, well placement becomes the largest obstacle to the establishment of a bedrock aquifer based public water system.

Several major factors dictate the suitability of a given location for the well including yield, infrastructure costs, property ownership, and most importantly, distance from contamination sources. During the consultant's visit on October 25-28, 2019, an attempt was made to identify potential sources of contamination that would affect setbacks.

4.2 Contamination Sources

The Maine DWP requires that all public drinking water wells be 300 feet from the nearest potential contamination source, which includes septic leach fields. Waivers are granted on a case-by-case basis for wells within the 300-foot radius, but locating the wells as far from potential pollution sources as possible is the best practice. The standard waiver criteria are briefly summarized below from the *Maine Department of Health and Human Services Well to Contamination Source Setback Waiver Policy for Public Water Systems*.

While not specifically stated in the manual, the implication is that the required effort to obtain a waiver is progressively more challenging as the requested setback radius is reduced. In other words, a waiver for a setback of 290 feet will be easier to obtain than a waiver for a setback of 110 feet. In most cases, professional services from a Maine-certified geologist may be needed.

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[8] https://www.maine.gov/dhhs/mecdc/environmental-health/dwp/fit/documents/NSAtransientSW.pdf

4.2.1 Setback = 150 to 299 feet

The eight circumstances preventing a new well to be drilled more than 300 feet from a potential contamination source

a) The size of the property is not sufficient to allow for the required setback
b) Sufficient setbacks from other potential sources of contamination cannot be met
c) Excessive slopes prohibit access
d) The location of permanent structures would result in unreasonable impacts or damage to the structures
e) The location of lakes, ponds, streams or wetlands prohibits meeting the required setback
f) The presence of bedrock at or within three vertical feet of the surface would result in unreasonable trenching requirements
g) Other requirement as accepted by the Maine DWP staff
h) The new well is a "Replacement Well" as defined by this policy.

- A public water system seeking to drill a new well must meet one of the eight circumstances that prevent a 300-foot setback from occurring. If none of the above circumstances apply, then the public water system must create a 300-foot-or-greater setback by drilling a well, moving a septic system leach field, or some other method.

- A public water system seeking to drill a new well with a setback of 150 to 299 feet, that fails to meet one of the reduced-setback circumstances, may hire a certified geologist to render an opinion concerning the risk of the well being contaminated by the leach field, based on the surficial geology between the well and the leach field. A setback of 150 to 299 feet may be waivered by a DWP geologist upon review of the information, data, and opinion provided by a certified geologist. Potential remedies to this reduced setback include septic pretreatment and/or well modification (e.g., installation of a Jazwell seal of an appropriate length), as approved by a DWP geologist. See *General Steps of a Hydrogeologic Assessment SOP ID: DWP0063-H Maine Drinking Water Program Page 4 of 9* (Appendix D of this report).

- For an existing well that fails to meet one of the eight circumstances allowing for a reduced setback, the DWP may issue a setback waiver.

- A waivered non community public water system with a setback between 150 to 299 feet must follow the water quality monitoring and well construction requirements from Table 1 and Table 2 of the *WT-IS Policy*. Monitoring and well construction requirements for Community systems are determined on a case-by-case basis.

4.2.2 Setback = 100 to 149 feet

- A public water system seeking to drill a new well must meet one of the above eight circumstances that prevent a 300-foot setback from occurring. If none of the above circumstances apply, then the public water system must create a 300-foot-or-greater setback by drilling a well, moving a septic system leach field, or some other method.

- A public water system with a setback of 100 feet to 149 feet that requires a hydrogeologic assessment may only receive a waiver if a DWP geologist reviews and approves such a waiver request.

- For both an existing well or a well that has not been drilled yet, a public water system that started operating or was substantially changed after 10/24/2001, per the Maine Rules Relating to Drinking Water: Must complete a hydrogeologic assessment appropriate to the system classification and situation as specified by a DWP geologist. The DWP geologist will approve or disapprove the evaluation. DWP Field Inspectors will instruct the public water system to contact a DWP geologist to discuss the requirements of a hydrogeologic assessment. If the DWP Geologist determines that a professional hydrogeologic assessment is necessary, the assessment must be completed by a Maine Certified Geologist. A hydrogeologic assessment may be waived if a certified geologist submits an engineered septic and/or well construction proposal that is then approved by the DWP. See *General Steps of a Hydrogeologic Assessment* (Appendix D of this report).

- A public water system that started operating or was substantially changed before 10/24/2001, with a well(s) drilled before 10/24/2001, is not required to complete a hydrogeologic assessment for that well. Note water quality monitoring requirements below. Note: A waiver of the hydrogeologic assessment based on the age of the system is only applicable for wells drilled before 10/24/2001. Conversely, any well drilled after 10/24/2001 must be evaluated using a hydrogeological assessment.

- A waivered non community public water system with a setback between 100 to 149 feet must follow the water quality monitoring and well construction requirements from Table 1 and Table 2 of the *WT-IS Policy*. Monitoring and well construction requirements for Community systems are determined on a case-by-case basis.

4.2.3 Setbacks less than 100 feet

- A public water system seeking to drill a new well must meet one of the above eight circumstances that prevent a 300-foot setback from occurring. If none of the above circumstances apply, then the public water system must create a 300-foot-or-greater setback by drilling a well, moving a septic system leach field, or some other method.

- A public water system with a setback of less than 100 feet that requires a hydrogeologic assessment may only receive a waiver if a DWP geologist reviews and approves such a waiver request.

- For an existing well, a hydrogeologic assessment is required, regardless of the establishment start date or substantial change date.

- For both an existing well or a well that has not been drilled yet, per Maine Rules Relating to Drinking Water, any system that started operating or was substantially changed after 10/24/2001 must complete a hydrogeologic assessment as specified above for setbacks of 100 to 149 feet. A hydrogeologic assessment may be waived if a certified geologist submits an engineered septic and/or well construction proposal that is then approved by the DWP. See *General Steps of a Hydrogeologic Assessment* (Appendix D of this report).

- A waivered non community public water system with a setback less than 100 feet must follow the water quality monitoring and well construction requirements from Table 1 and Table 2 of the *WT-IS Policy*. Monitoring and well construction requirements for Community systems are determined on a case-by-case basis.

In the case of Monhegan Island, the ocean can be considered a contamination source as well, due to the threat of saltwater intrusion. In the *Monhegan Island Well Water Study*, the consultant found none of the 10 bedrock wells chemically analyzed indicated evidence of current saltwater intrusion.

Additional bedrock wells on the island were measured for their depth to water from the surface elevation, to estimate the thickness of the freshwater lens beneath the island's surface. According to the simplified Ghyben-Herzberg principal, the lens extends 40X further beneath sea level than it extends above sea level into the bedrock aquifer. This means that even a modestly shallower depth to water observed in a well could mean that the freshwater lens extends significantly further beneath the surface. In general, wells with shallow depth to water and larger distances from the coastline make the well more resistant to saltwater intrusion.

While none of the wells sampled on the island exhibited elevated indicators that saltwater was entering the well in appreciable quantities, there was a trend of higher chloride and suspended solids noted in wells closer to the coast, meaning that there was a hydraulic influence between the bedrock wells and the ocean water. While these private bedrock wells were not experiencing prohibitively high levels of saltwater derivatives, a public water system well which draws water on a consistent basis, could create a strong enough hydraulic gradient to cause saltwater intrusion concerns if the well is located too close to the coast. Thus, we recommend that any public water system well be at least 300 feet from the coastline, but preferably at least 800 feet away. The MISCA well is just over 800 feet from the shoreline and had among the lowest chloride levels, total dissolved solids, and conductivity of the wells tested on the island. **However, that the MISCA well is within 100 feet of a septic leach field and would need to meet the most stringent of waiver conditions to be approved for public water system use, as well as the water quality monitoring and well construction requirements in the *WT-IS Policy*.**

4.3 Infrastructure Cost

In order to limit the cost of installation of a new supply source, the installation of a new well should be placed as close as possible to two 17,000-gallon steel standpipes which currently provide storage and pressure for the water from the meadow aquifer. In addition to providing a more resilient supply source a major goal of a new public water system is to have the source available year-round. Currently, the meadow aquifer sources must be shut down and drained before each winter in order to prevent damage to the system because large parts of the transmission and distribution system are located on the surface or slightly below grade. Locating the new wells within a reasonable distance from the water tanks would reduce the distance of trenches for transmission lines, which would lead to substantial savings of money and manpower.

Drilling a more remote well within a reasonable distance of Maine Street could be justified because the new system's distribution system would likely need to be installed in a trench in order to reach Deadman's cove, but there are still additional costs with extending the electrical service and transmission piping over long distances. In summary, is recommended that the well be placed no more than 1000 feet from the tanks, but certain outlying locations could be considered with the understanding of increased costs.

4.4 Property Ownership

The majority of Monhegan Island's *parcels* are small and privately owned, however the majority of Monhegan Island's *land area* is municipally owned or owned by semi-private trusts and conservation organizations. It is in these latter three categories that the most desirable parcels for land construction lay. These parcels likely have the space to place a well far enough from contamination sources so as not to run afoul of the Maine Drinking Water Program regulations. All of the potential well locations explored in this report are on municipally owned land.

4.5 Potential Drilling Locations

4.5.1 Outside of 300 Foot Setback

There are two feasible locations outside a 300-foot sanitary setback. These locations would not require a waiver to develop.

The large 108-acre parcel (Plan 10 Lot 1) that contains the power station and transfer station is the most likely candidate for well placement. A test well was already drilled near the power station, which had a very shallow depth to water of less than 10 feet. This coupled with the wellhead's high elevation on the island means that the freshwater lens is exceedingly thick in this area. Based on readings taken at the private residence near the lighthouse, it is estimated that freshwater extends over 4500 feet below sea level in this area.

The most logistically desirable location within the parcel would be located on White Head Trail, so that it is approximately 400 feet east of both the power station and the dumpsters. The elevation rises to 142 feet in this area, approximately 10 feet above that of the nearest contamination source. This distance would place the well outside of the sanitary radius and would make the risk of contamination from a release much less likely. This location is also far away from any private property, lessening the chance of future threats to the local groundwater in the area. A well drilled in this area would be approximately 750 feet from the storage tanks, but no private properties would need to be crossed during the trenching. This means that a relatively straight trench could be excavated, which would simplify the effort and reduce cost.

Another possible location within the parcel is placing the well approximately 750 feet north of the power station, along the road. This area is free of any significant development but would require a 1000-foot trench through the woods to reach the storage tanks, or 1,500 feet of trenching along the roadway. The obvious issue with this parcel is the potential for pollution from both the power station, and the septic systems for the lighthouse and a private property. The power station runs on diesel fuel, which is stored in protected above ground storage tanks. Further analysis would be required to determine which direction a release from these tanks would travel, and what risk these contaminants would pose to a well located in the general area.

4.5.2 Within 150 to 299 Feet of Contamination Source

A well located approximately 25 feet east of the storage standpipes on municipal property would be less than 300 feet from the nearest septic leach field and the dumpsters, but more than 150 feet away from any contamination source. This location has the advantages of being very close to the standpipes, on very level ground, and being upgradient of the contamination sources, based on the 2-foot contours. A further hydraulic analysis would need to identify the fracture orientation to determine the direction of groundwater flow.

4.5.3 Within 100 to 149 Feet of Contamination Source

A well could be placed in the grassy area to the west of the Monhegan Island Lighthouse driveway. This would be relatively close to the standpipes, would not require trenching through private property, and would be easily accessible. This location is approximately 130 feet from the assumed location of the lighthouse septic leach field; however, the argument could be explored that this is a relatively lightly used septic system which would have a low impact on the groundwater quality.

4.6 Bedrock Fracture Analysis and Implications for Recommended Sites

Bedrock fractures were mapped by the consultant on October 26, 27, and 28, 2019. Figure 4-1 shows the location of the bedrock outcroppings that were characterized, and the accompanying Table 4-1 shows the observations recorded at each outcropping.

This work was completed with a Brunton pocket transit. The transit is a type of compass that measures the strike and dip of fractures by employing standard geologic field methods available to professionals who possess a degree in geological sciences.

The fractures observed on Monhegan Island are primarily joints and shear fractures in gabbro rock. These are fractures of natural origin where lateral movement has been minor, unlike faults where lateral movement (whether vertical or horizontal) was once significant and caused by tectonic forces. Joints and shear fractures can be classified by formation (cause) or by geometry. Efforts to characterize causes of fractures on Monhegan Island were not made, but it is likely that most were caused by prehistoric and/or post-glacial unloading of rock and sediments that formerly existed over the island. Relative to geometry, most of the observed fractures appeared to be:

- Orthogonal Joints – these occur when the joints within the system occur at mutually perpendicular angles.
- Conjugate Joints – these occur when the joints intersect each other at angles significantly less than 90 degrees.
- Systematic Joints – these are joint systems in which all the joints are parallel or subparallel, and maintain roughly the same spacing.

The bedrock fractures of Monhegan Island are important in their roles for groundwater hydrology and water supply. As noted in Section 3.2, the bedrock aquifer comprises nearly the entire island and contains numerous fractures which represent narrow reservoirs for fresh water. If fractures are abundant and well-connected, groundwater originating from precipitation on the ground surface will travel through numerous sets of intersecting fractures to discharge along the shoreline and in the seabed around the island. If fractures are infrequent or poorly connected, groundwater originating from precipitation on the ground surface will have a more challenging route to the ocean.

Approximately 50 sets of fracture measurements were taken at outcrops over three separate days. The area of focus was mainly south of Cathedral Trail and north of Alder Trail, and included:

- Populated areas where private bedrock wells are located;
- Parcels near the lighthouse and water tanks that may be available for bedrock well development by the Water Company due to land ownership or lease agreements; and
- Areas visible from Cathedral Trail, Long Swamp Trail, Red Ribbon Trail, Whitehead Trail, and Alder Trail.

According to De Wet (2007) in his work on Vinalhaven, *"In most locations there is one dominant vertical fracture orientation and a sub-horizontal 'unroofing' fracture orientation. The sub-horizontal fractures parallel the topography and are laterally fairly continuous but decrease dramatically in frequency with depth (as seen in numerous granite quarries across the island). These sub-horizontal fractures probably dominate the recharge of dug and shallow wells and raise the possibility of contamination from relatively unfiltered surface water. The distribution, orientation and pattern of the vertical fractures is complex and varies across the island. These fractures probably dominate recharge to the deep wells. Faults and shear zones are relatively uncommon."* These statements are likely representative of Monhegan Island, as well, with the exception of the specific bedrock type.

Figure 4-1: Chacterized Outcrops

Alternate Water Supply Feasibility Study
Monhegan, Maine

1 inch = 300 feet

MILONE &
MACBROOM
99 Realty Dr
Cheshire, CT 06410
203-271-1773

Outcrop Notes Table
Monhegan, Maine

Outcrop Number	Strike	Dip	Strike2	Dip2	Notes	Strike3	Dip3	Strike4	Dip4
1	N 22 E	Vertical	- - -	- - -	GW seeping from slope fractures not evident basalt	- - -	- - -	- - -	- - -
2	N 42 E	86 W	- - -	- - -	Lighthouse outcrop, basalt?	- - -	- - -	- - -	- - -
3	N 30 W	80 W	N 90 E	78 N	Lighthouse rear	- - -	- - -	- - -	- - -
4	N 65 E	Unattainable	N 70 E	Unattainable	Fracturing not evident	- - -	- - -	- - -	- - -
5	N 60 E	78 E	N 90 E	- - -	1, foliation strike metamorphic 2, unusual joints	- - -	- - -	- - -	- - -
6	N 55 W	60-5 S	- - -	- - -	realistic fracture, 2 outcrops 4' apart	- - -	- - -	- - -	- - -
7	N 65 W	50 S	- - -	- - -	seepage from rock	- - -	- - -	- - -	- - -
8	N 55 W	62 S	- - -	- - -	- - -	- - -	- - -	- - -	- - -
9	N 57 W	62 S	- - -	- - -	- - -	- - -	- - -	- - -	- - -
10	N 15 W	Vertical	N 5 W	Vertical		- - -	- - -	- - -	- - -
11	N 52 W	76 S	N 52 W	62 S	Major coastal set of fractures, mostly all N50-55W	- - -	- - -	- - -	- - -
12	W 90 E	40-45 N	- - -	- - -	Major coastal fracture	- - -	- - -	- - -	- - -
13	N 10 E	Vertical	- - -	- - -	At least 2 outcrops, 1.5' apart	- - -	- - -	- - -	- - -
14	N 16 W	82 W	N 15 W	83 W	~1 foot apart, but converge	- - -	- - -	- - -	- - -
15	N 70 W	83 N	- - -	- - -	At least 4 outcrops 2' apart	- - -	- - -	- - -	- - -
16	N 6 E	65 W	- - -	- - -	2 -3 joints a foot apart	- - -	- - -	- - -	- - -
17	N 15 W	71 W	N 49 E	83 N	- - -	N 30 E	83 N	- - -	- - -
18	N 43 W	75 W	- - -	- - -	- - -	- - -	- - -	- - -	- - -
19	N 60 W	60 W	- - -	- - -	Very close to #18	- - -	- - -	- - -	- - -
20	N 70 W	Vertical	- - -	- - -	- - -	- - -	- - -	- - -	- - -
21.1	N 75 W	37 S	N 85 W	40 S	Slickensides imply major fractures of S/D1&2	- - -	- - -	- - -	- - -
21.2	N 42 E	78 E	- - -	- - -	Across stream from #21	- - -	- - -	- - -	- - -
22	- - -	- - -	- - -	- - -	Massive, rounded, cannot find structure	- - -	- - -	- - -	- - -
23	N 22 W	Vertical	N 56 W	70 W	Intersecting joints in pathway	- - -	- - -	- - -	- - -
24	N 32 E	76 E	- - -	- - -	- - -	- - -	- - -	- - -	- - -
25	N 20 W	62 W	N 10 W	Vertical	Joint 6' apart	- - -	- - -	- - -	- - -
26	N 86 W	87 S	N 70 W	84 S	Joints ~4' apart	- - -	- - -	- - -	- - -
27	N 80 W	67 S	- - -	- - -	Joints ~4' apart	- - -	- - -	- - -	- - -
28	N 80 W	84 S	- - -	- - -	Joints ~3' apart	- - -	- - -	- - -	- - -
29	N 38 W	74 W	N 36 W	75 W	Joints ~2' apart	N 40 W	Unattainable	- - -	- - -
30.1	N 80 E	Vertical	- - -	- - -	~20 feet from other #30	- - -	- - -	- - -	- - -
30.2	N 80 E	Vertical	- - -	- - -	- - -	- - -	- - -	- - -	- - -
31	N 35 E	72 W	- - -	- - -	- - -	- - -	- - -	- - -	- - -
32	N 17 E	Vertical	N 20 E	Vertical	3 sets outcrops: 1&2 ~3' apart	N 48 W	77 South	N 85 W	78 S
33	N 70 E	40 N		- - -	Major coastal set - sight methods	- - -	- - -	- - -	- - -
34	N 85 W	80 S	- - -	- - -	Front steps red house, at least 3, ~1-2' apart	- - -	- - -	- - -	- - -
35	N 85 E	80 S	- - -	- - -	Seaward, next to school	- - -	- - -	- - -	- - -
36	N 45 - 55 E	42 W	- - -	- - -	Between shed and neighbor	- - -	- - -	- - -	- - -
37	N 55 E	60 W	- - -	- - -	By placard, 2 are ~1.5' apart	- - -	- - -	- - -	- - -
38	N 45 E	34 W	- - -	- - -	Beyond placard, 2 are ~5' apart	- - -	- - -	- - -	- - -
39	N 5 W	62 W	N 85 E	Vertical	1 is 5' apart, 2 is 4' apart	- - -	- - -	- - -	- - -
40	N 15 W	83 E	- - -	- - -	Big area of outcrops, ~3 joints	- - -	- - -	- - -	- - -
41	N 80 W	Vertical	- - -	- - -	Big area of outcrops, variation in strike	- - -	- - -	- - -	- - -
42	N 90 E/W	Vertical	- - -	- - -	N red house, exerts some control on inlet	- - -	- - -	- - -	- - -
43	N 63 E	47 N	- - -	- - -	Near breakwater, different basalt formation	- - -	- - -	- - -	- - -
44	N 45-40 E	74 E	- - -	- - -	South of breakwater, dip toward island	- - -	- - -	- - -	- - -
45	N 60 W	Vertical	N 68 W	Vertical	Set of 3 weak joints all near vertical 1-2' apart	N 70 W	Vertical	- - -	- - -
46	N 70 E	Unattainable	- - -	- - -	No fractures, strike is center of formation	- - -	- - -	- - -	- - -
47	N 35 E	Unattainable	- - -	- - -	Very weak joint trace, one outcrop on hill	- - -	- - -	- - -	- - -
48	Foliation E/W	Unattainable	- - -	- - -	Cannot see jointing or dips	- - -	- - -	- - -	- - -

The northern and southern sections of the island were not included in the focus area for bedrock fracture mapping, as they are too distant from areas where water supply could reasonably be developed; and because sufficient fracture traces could be identified in the central parts of the island. In general, three types of outcrops were observed and therefore available for mapping:

1. Highly fractured outcrops were abundant along the west and east shorelines in the area of focus (in other words, near Swim Beach and at the ends of Cathedral Trail and Alder Trail). Shoreline areas were intensely fractured, and care was taken to ensure that the fractures given attention were representative of the bedrock fracture structure rather than wave energy.
2. Relatively smooth and flat outcrops were visible in populated areas, typically where residential development, roadmaking, and other activities have altered the landscape. Fractures were more challenging to map in these outcrops.
3. A few large blocky outcrops were observed in undeveloped interior parts of the island.

Examples are pictured below. It is important to note that some observed outcrops did not fit entirely within these descriptions.

1. Shoreline Outcrops

2. Flat Outcrops

3. Blocky Outcrops

According to Maine Geologic Society (Marvinney[9], 2010) basalt dikes cut through and across the gabbro in several parts of Monhegan Island. While these dikes may exert some influence on the hydrogeology where they occur, they did not appear to be significantly different than the gabbro relative to the number and types of fractures. Some of the outcrops appeared to consist of basalt but they were fractured similarly to the gabbro outcrops. Unique columnar fracturing that is typical to some basalt formations was not observed.

Many fractures were found in all orientations with a variety of strikes and dips, except that *only one* fracture had a strike oriented between zero to 10 degrees east of north (this is the shortest bar on the rose histogram on the next page). The most common strikes were about 90-100 degrees east of north (in other words, mostly west-east) and 50-60 degrees west of north. Overall, the rose histogram on the next page (showing total counts of fractures per ten-degree span) of the most common strike orientations appears to show that most fractures are oriented west-northwest to east-southeast. Interestingly, most of the fractures are oriented oblique to the overall northeast-southwest orientation of the island. However, it is important to note that there was not a single ten-degree interval in the rose diagram that lacked a fracture.

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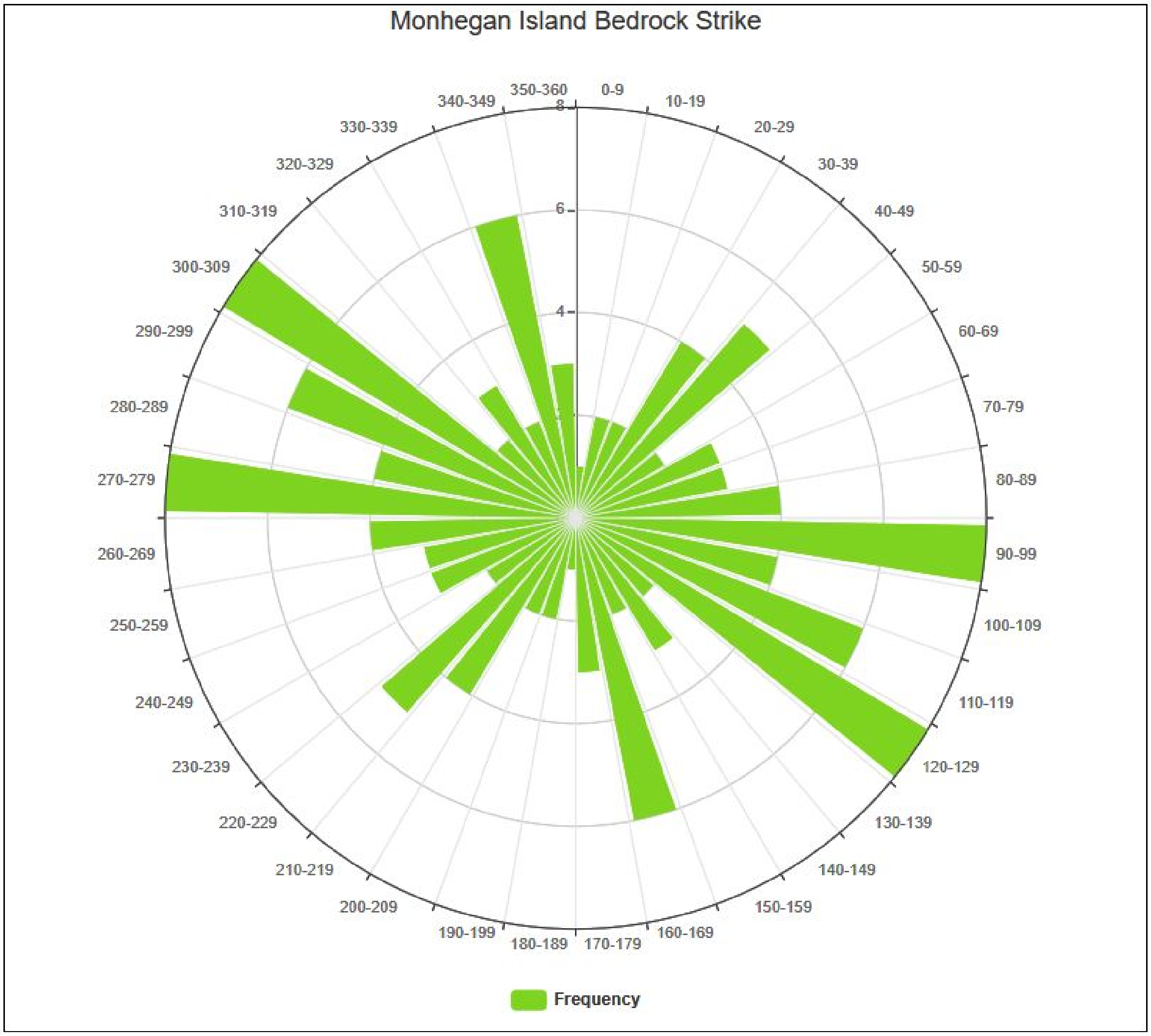
[9] https://digitalmaine.com/cgi/viewcontent.cgi?article=1446&context=mgs_publications

The dips of most fractures were steep, varying from 50 degrees to near vertical (90 degrees). Only a couple fractures had more shallow (less steep) dips on the order of 30 to 40 degrees. The presence of many inclined and vertical fractures likely allows a high degree of recharge of the bedrock aquifer from the ground surface. Coupled with the high variety of fracture strike orientations, the numerous fractures of the island's bedrock are likely interconnected and allow for relatively easy withdrawal of groundwater from private wells.



The fracture orientations and dips of the island's bedrock neither point to – or away from – any specific areas for future groundwater supply development. One is likely to encounter bedrock fractures in a bedrock well of sufficient depth. Ideally, evidence of a greater number of fractures with gentle dips would have been found on the island; this would have allowed for development of bedrock wells with different depths (some relatively shallow and some deeper).

As a component of the bedrock outcrop analysis, linear features (such as lineaments) in the bedrock were observed using a stereo pair of aerial photographs. The sole available stereo pair represents a flight conducted in

September 1980. The island was viewed with some moderate "relief" visible from the stereo pair. The visible dominant lineaments include:

- Five traces trending northwest-southeast (strike approximate N58W), all located in the northern half of the island
- One trace trending N12E at the northeast corner of the island
- One trace trending N42E at the southeast corner of the island

Lineaments were not visible in the populated portions of the island and in the vicinity of the meadow aquifer.

Of the visible lineaments, only the five traces trending N58W are aligned with one of the longer green bars in the rose histogram. The lineament trending N42E is aligned with one of the medium-length green bars in the rose histogram, and the lineament trending N12E is aligned with a relatively short bar in the rose histogram.

Unfortunately, stereo pair observation was not as revealing as anticipated. Similar to the fracture mapping, the bedrock lineaments visible through stereo pair observation neither point to – or away from – any specific areas for future groundwater supply development.

4.7 Conclusion

While there are relatively few areas that would present idealized locations for a new public water system well, sufficient land area is available on the 108-acre municipally owned parcel (Plan 10 Lot 1) for a fair amount of flexibility as to well locations. While locations in the immediate vicinity of the standpipe are valid options and will likely cost less to install and connect to the system, they may be saddled with additional regulatory hurdles and preparation of a Hydrogeologic Assessment by a Maine-certified geologist. The most favorable location would be the area approximately 400 feet east of the powerplant on White Head Trail, because this location is easily accessible, out of range of contaminant source setbacks, and is surrounded by conserved land that would likely preserve water quality in the future. This location is at a low risk of saltwater intrusion due to both its horizontal and vertical separation from the ocean.

APPENDIX A

Numerical Model Files

Zipped file provided separately:

"1990 Calibration"
"TransientAnnual"
"Predictive"

APPENDIX B

Timson (1991) Report

MONHEGAN MEADOW AQUIFER

AQUIFER CHARACTERIZATION AND WATER QUALITY STUDY

FINAL REPORT

Prepared For:

The Monhegan Plantation Planning Board
Monhegan, Maine 04852

Prepared By:

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TIMSON, SCHEPPS & PETERS, INC.
P.O. Box 150
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January 3, 1991

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SUMMARY

- A pump test conducted on a single well point of the present Monhegan Water Company well field yielded results to define the aquifer unit beneath the meadow as a "leaky" aquifer, deriving additional water from an overlying restrictive clay bed above the aquifer unit, a glacio-marine sand. Values of the aquifer transmissivity (1850.9 gallons per day per foot), hydraulic conductivity (61.7 gallons per day per square foot) and storativity (.0074) indicate that the aquifer is suitable for pumping domestic water supplies, with a moderate to high permeability.

  Distance-drawdown curves indicate that a single, 2"-diameter well, pumped at a rate of 5 gallons per minute, draws water from as far away as 350 feet within the aquifer.

- The water quality of the aquifer, both at the well field and along the southern and western margins was tested and found to be adequate for drinking purposes after chlorination. Higher than drinking water standard values for sodium, iron and manganese were found, but not to excess. The levels of these constituents are deemed the result of the natural chemistry of the aquifer setting, and not due to human contamination of the water. Water turbidity, color and hardness were also found to exceed recommended levels, but elevated levels of these characteristics are not deemed harmful to human health.

  Water quality sampling at the edge of the aquifer indicate that there is little contamination of the aquifer water along the southern andwestern margins where shallow ground water is expected to have higher than acceptable values of nitrate-nitrogen and fecal coliform bacteria from subsurface sewerage leach fields. Values of nitrate-nitrogen were found to be close to those of expected natural background and bacterial levels in the samples were also low. Shallow ground water migration through the peat deposits overlying the aquifer, prior to entering the aquifer, provides for natural filtration and absorbtion of bacteria, viruses and nitrate-nitrogen.

- Geologic studies of the meadow landward of Swim Beach provide evidence that the aquifer glacio-marine sand is in direct contact with Swim Beach littoral deposits and, therefore, in direct hydrologic contact with marine waters in Monhegan Harbor. Head pressure and density differences between the meadow water and oceanic water keep the salt-water interface from migrating into the aquifer.

- Consideration can be given to placing a well point approximately 100 feetfurther west toward the center of the aquifer in order to tap unused portionsof the aquifer water supply and without threat of inducing salt-water intrusion or intercepting leachate plumes from nearby, upland septc leachfields. If undertaken, the well should be no larger than 2" in diameter (limited to a 5 gallon per minute yield) and water quality sampling conducted monthly during a season's use to ensure that the water is of adequate quality.

ACKNOWLEDGEMENTS

The author would like to acknowledge the contributions of Mr. Willard Boynton and Daniel Bates to the successful completion of this project. Bill Boynton, Monhegan's First Assessor, Chairman of the Planning Board and Director of the Monhegan Water Company enthusiastically supported this project and provided the author with invaluable background information, without which this report would suffer greatly. Both Bill and "Danny" Bates assisted personnel from Timson, Schepps and Peters, Inc. in conducting the pump test, lugging heavy equipment, and providing for logistical support.

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Finally, to the residents, both year-round and seasonal, whose continued interest in their water supply initiated this study, I am grateful for their acceptance and enthusiasm for my interest in providing the Monhegan community with useful information from which they might plan a better future.

David Pickart, Associate Scientist with Timson, Schepps & Peters, Inc. worked on this project with the author. Mark Sullivan, nephew of the author, assisted in surveying and the collection of water quality samples.

1.0 INTRODUCTION

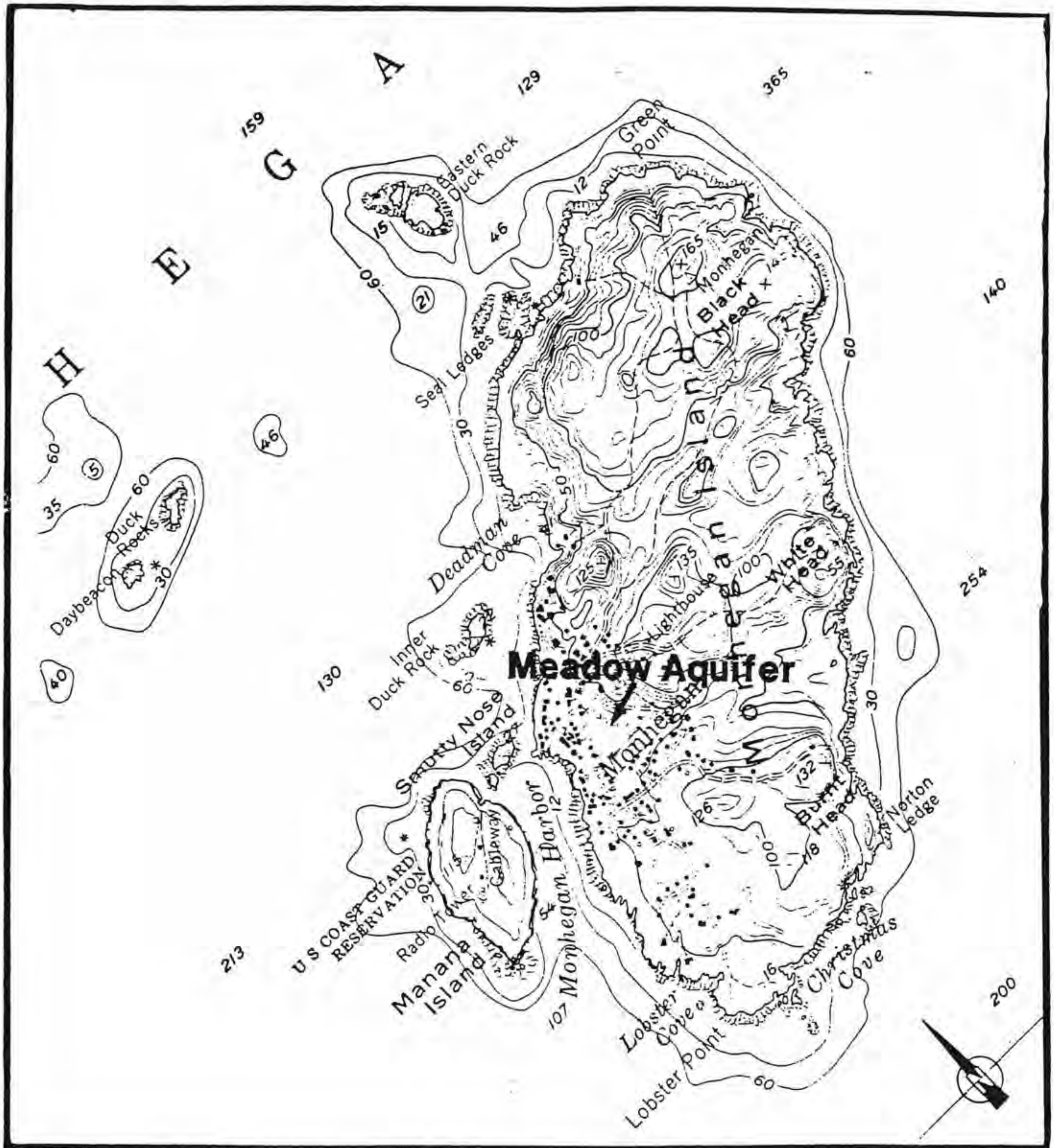
This report constitutes the results of the Monhegan Meadow Aquifer Characterization and Water Quality Study funded under the Maine 205(j)(1)-(3) Program. The project is administered by the Monhegan Plantation Planning Board under a grant from the Maine Department of Environmental Protection.

Monhegan Plantation is an unorganized township located on the island of Monhegan. This island lies offshore and due south approximately 10 miles from the mainland village of Port Clyde, Knox County, Maine. The area of the island is about 0.8 square miles and it is approximately 3,000 feet wide by 8,500 feet long (Figure 1). Directly west of the island of Monhegan is a smaller island, Manana.

The island supports a small year-round community of approximately 85 inhabitants, primarily supported by commercial fishing. This population increases dramatically during the summer months when seasonal residences, inns and guest houses are occupied. Additionally, three tourist boats transport day visitors to the island from Boothbay Harbor, New Harbor and Port Clyde, mainland ports, each day between Memorial Day and Labor Day. The island is a popular summer retreat for artists and a common visiting place for bird watchers, especially during the spring and fall shorebird migrations.

From May 1 to November 1 of each calendar year, the island community relies almost solely on a chorinated public water supply drawn from a sand and gravel aquifer located beneath "The Meadow", a bog wetland. This wetland lies within the heart of the developed village area on the western side of the island (Figure 1) and is separated from the open ocean by a low bedrock high which is less than 100 feet in width at its shortest point. During the remaining months of the year, year-round residents utilize several drilled bedrock wells, dug wells, and cisterns for water supplies. Salt water and surface stream water are utilized by several commercial businesses to limit their dependency on freshwater supplies delivered by the public water supply. It is estimated that 80% of the potable water consumed on the island on a year-round basis is derived from the Meadow Aquifer (Maine State Planning Office, 1988).

This public water supply for Monhegan is an U.S. Environmental Protection Agency designated "sole-source" aquifer. The aquifer



MONHEGAN ISLAND

FIGURE 1

Scale:

0 1000 2000 Feet

Source: **USGS 7.5 Monhegan Quad.**

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is a deposit of glacio-marine, fine to coarse sand with calcium carbonate, shallow marine shell fragments which infills a basin within the igneous rock island topography (Timson, 1989)(Figure 2). Post-glacial uplift and subaerial exposure of this former shallow marine basin has allowed for its subsequent conversion to an isolated freshwater pond, infilling with lacustrine clays and freshwater peat deposits over the last ten thousand years (Timson, 1989)(Figure 2).

The Monhegan Water Company maintains a well field of about 15 active and abandoned points in the west central portion of the meadow (Figure 2)(Photographic Plate A). The water supply is presently pumped through five to eight active and developed points, all within 100' of each other. Each point consists of a 3' length of stainless steel screen, 2" in diameter. The water pumped from the aquifer is delivered through 1 and 7/8 inch, inside-diameter, steel pipe to diesel pumps which feed two, 17,500 gallon standpipes and approximately 20,000 feet of surface distribution steel and PVC pipe. Under present normal operating conditions, the active point system (5 well points) delivers a steady yield of 25 gpm (Willard Boynton, 1990). Based upon previous boring information and present well point depths from this area of the meadow, the points most commonly used for delivering water range in depth from 47' to 65' below the meadow surface and are driven into the aquifer sand which ranges in thickness from 9' to 15' in this area of the aquifer.

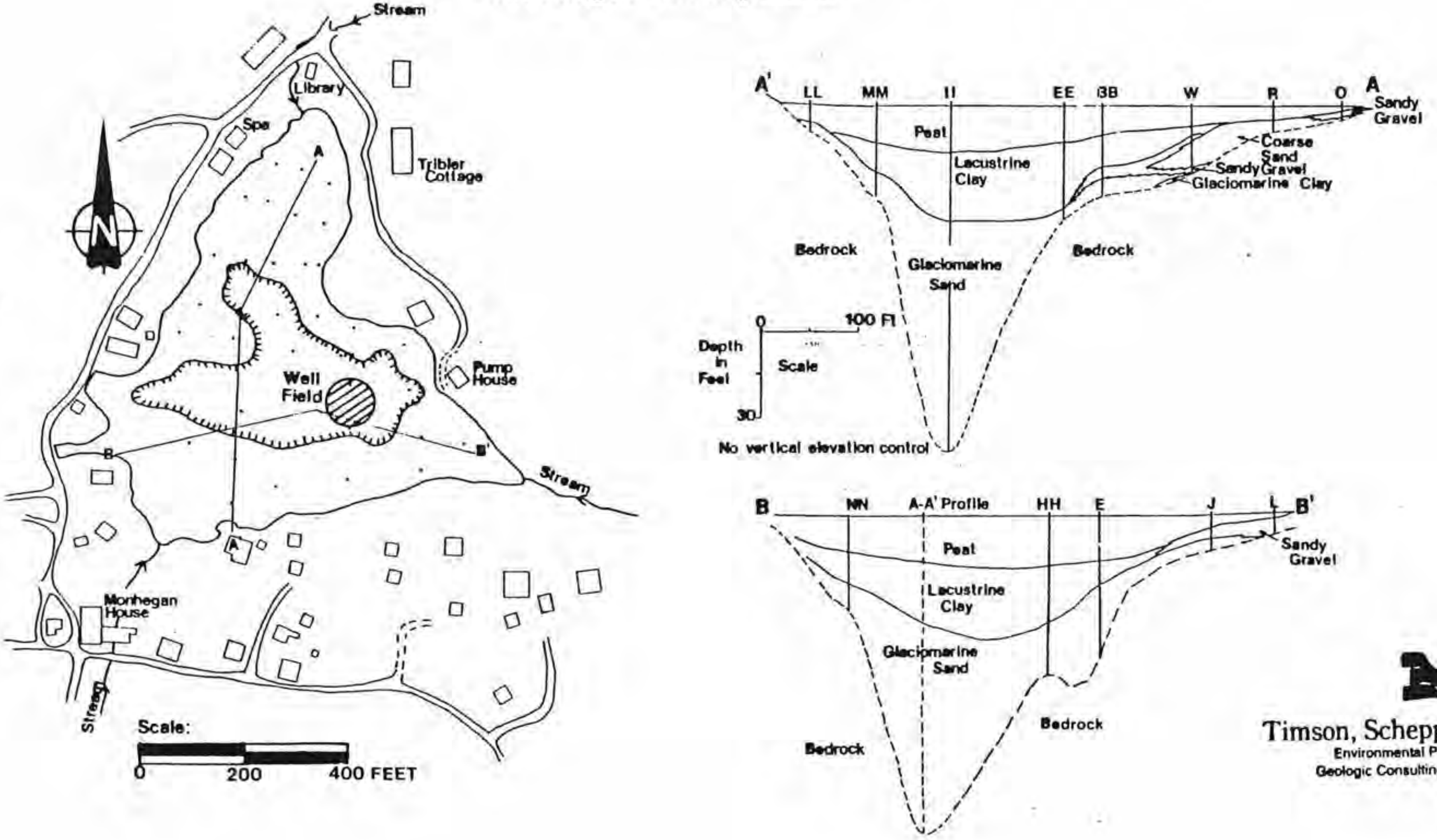
In 1988, approximately 3,125,000 gallons of water were withdrawn from the aquifer from between June 1 and September 3 to supply island demands. In 1989, approximately 2,500,00 gallons were withdrawn from the aquifer between May 14 and September 5. Volume withdrawal records previous to 1988 do not exist.

2.0 OBJECTIVE OF THE AQUIFER CHARACTERIZATION AND WATER QUALITY STUDY

Previous geologic and hydrogeologic investigations of the Monhegan aquifer defined the geology, origin and capacity of the aquifer sand underlying the meadow peat bog (Timson, 1989). Consideration of the recent withdrawal records suggest that water demand from the aquifer during drought conditions, coupled with high seasonal population visits to the island, could lead to a water demand which exceeds the short-term summer season "safe" rate of recharge as well as overtaxing the current systems' capability of delivering the required volumes of water. Additional data,

Figure 2

Geologic Cross Sections: The Meadow
Monhegan Island, Maine



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however, indicated that system delivery problems might be overcome by upgrading the system by moving active well points further east in the meadow and withdrawing water from deeper areas of the aquifer. Because of known salt-water intrusion problems in bedrock wells close to the island's shoreline and possible water quality problems associated with surface streams and subsurface sewerage disposal systems located along the western margin of the meadow, the implications of down-grading the water quality of the aquifer by altering the delivery system needed to be evaluated.

The objectives for this study were the following:

A. define the hydraulic and hydrogeologic characteristics of the aquifer, such as its hydraulic conductivity, storativity and transmissivity, in order to predict the aquifer's response to upgrading the Monhegan Water Company well point system by moving it deeper and further west within the aquifer;

B. determine the present water quality of the aquifer water prior to its treatment by chlorination by the Monhegan Water District, both at the active well system location and at its margin where shallow ground water recharge to the aquifer is likely to be effected by polluted stream inflow and leachate plumes from subsurface sewerage treatment leachfields; and

C. determine the western geometry of the aquifer to ascertain if a direct hydraulic connection with the ocean exists, especially in the area of Fish Beach. A potential threat of salt-water intrusion would exist if such a direct hydraulic connection between the aquifer and the ocean does occur.

The following studies were conducted in order to provide the necessary data to meet the objectives:

- A pump test of one of the active Monhegan Water Company's well points was conducted for 24 hours while monitoring the water levels in two additional well points. The pump test would help determine the hydraulic and hydrogeologic characteristics of the aquifer in the vicinity of the active well field.

- A water quality sampling program to determine the aquifer's water quality, both at the active well field as well as along the southern and western margins of the aquifer. Water quality analyses would also be conducted on samples from the aquifer at the beginning of its seasonal use, as well as after a season's removal of aquifer water.

- A coring and boring program was conducted along the western area of the aquifer in the vicinity of Fish Beach to determine the geometry of aquifer deposit in this area.

3.0 THE AQUIFER PUMP TEST AND AQUIFER CHARACTERIZATION

3.1 Planning Phase

The purpose for conducting the pump test on selected wells within the well field was to provide pumped draw-down and recovery water level measurements to "characterize" the basic properties of the aquifer in order to evaluate and protect the existing water quality of the aquifer.

In addition to undertaking a pump test, water samples were collected directly from the aquifer wells -- one sample prior to conducting the pump test and one sample immediately after conducting the pump test. These water samples were analyzed for Maine primary and selected secondary drinking water constituents by a qualified analytical laboratory (Appendix 2). They represent the first water quality samples collected directly from the aquifer. All previous sampling conducted by the Monhegan Water Company was from domestic faucets after the aquifer water had passed through the chorination apparatus and the pipe and temporary storage system of the water company. The purpose for collecting and analyzing the aquifer water samples was to establish a baseline overall quality for later comparison with water samples collected from the margins of the aquifer, near domestic subsurface sewerage system leachate flow paths and with a water sample collected from the pump well after a season's withdrawal of water from the aquifer.

Prior to conducting the pump test, a visit was made to Monhegan (May 9 and 10, 1990) to review the present well field and select a series of wells to conduct the pump test and water level observations from. Based upon information from Monhegan Water Company personnel, three wells were initially selected for pumping and water level monitoring, such that the observation wells were approximately 50' and 100' distant from the well to be pumped.

The pumping well was to be the deepest well point penetrating the aquifer (65.1'). Additionally, company personnel and several other islanders agreed to sink a fourth well point, adjacent to the pump well, in order to monitor the water level changes in the pumping well, a condition otherwise impossible to monitor under the existing pump setup.

It was agreed upon that the pump test would be conducted on May 29 and 30, 1990, prior to the opening of most of the inns on the Island, as well as prior to the Memorial Day weekend when the Monhegan "tourist" season officially begins. The Monhegan Water Company had initiated pumping for the season two weeks previous to this date. Pumping was to cease at least 24 hours prior to the planned date of the pump test to allow the piezometric surface of the aquifer to return to an equilibrium state.

The second trip to Monhegan occurred on May 28, 1990, to prepare for the pump test on the following day. The pump test was initiated on the morning of the May 29th. Prior to initiating the pump test, a water sample was taken from the well to be pumped. The water sample was collected from a teflon bailer which had been rinsed three times with distilled water. The sample was discharged into a sterile plastic bottle and placed on ice within a cooler for later transport to the analytical laboratory for analysis. Pumping was initiated around 11:00 AM.

As occurs in many situations, the point selected for pumping would not deliver a steady yield. The pumping rate was measured from a by-pass pipe faucet located within the delivery system after the pump. Flow into a 5-gallon bucket, calibrated in 1-gallon increments, was timed to determine the yield. The yield from the selected well ranged from 1 to 2 gallons per minute, a level below the capacity of the well and pump. Operations ceased within a half-hour to select a new set of well points for delivery and water level monitoring, check the lines for leaks, and replace the pump leathers.

After selectively testing several points, a new set of points were selected for pumping and observation. Establishment of a new set of points did not allow for an observation well to be located directly adjacent to the pumping well, limiting the number of monitoring wells to 2, situated approximately 25' and 50' from the pumping well.

The parameters of the pump and observation wells utilized for the pump test are provided in Table 1.

TABLE 1

Pump and Observation Well Parameters: Monhegan Aquifer Pump Test May 30, 1990

Well#	Well Depth*	Point Diam.	Pipe Diam.	Dist. from MPW-1	Initial Level*
W-1	36.3'	2"	1-7/8"	0.0'	15.12'
W-2	51.0'	2"	1-7/8"	25.47'	15.04'
W-3	46.9'	2"	1-7/8"	46.9'	15.10'

* Well depth and water level data initially recorded from top lip of riser pipe. Elevations of each well were subsequently determined by survey tie to U.S.G.S. bench mark ID#4 at a later date after all monitoring wells were installed.

U.S.G.S. Bench Mark ID#4 is located on a ledge outcrop located along the south side of the main island road, approximately half-way from the public landing to the Island Inn. The elevation of this Bench Mark is +27.80' above mean low water. All subsequent elevations are based on MLW as a datum.

Locations of all wells are presented in Plate 1 of this report.

The pumping rate was determined by filling a calibrated bucket on 10 different occasions during the pump test. The flow rate averaged 5 gallons per minute over the duration of the test, but ranged from 3.8 to 6.3 gallons per minute.

After the pump test was conducted, a rising head or water level recovery test was conducted in the pumped well, W-1. Water level recovery measurements were taken every minute up to 15 minutes after cessation of the pumping, every 5 minutes up to 20 minutes and every 10 minutes up to an hour after pumping stopped.

A second water sample was collected from the pumped well immediately after pumping ceased. This sample was transferred to a sterile plastic jar and placed on ice for later transport to an analytical laboratory.

3.3 Results of the Pump and Recovery Tests

The results of the pump and recovery tests on wells W-1, W-2 and W-3 are plotted on semi-log graph paper (Figure 3) and 3 x 5 cycle logarithmic graph paper (Figure 4).

The water level drawdown points from the two observation wells, when plotted on semi-log paper, plot as straight lines which are parallel to one another, typical of confined aquifer equilibrium drawdown behaviour, with the exception of the drawdown behaviour in well W-2 after 4 hours of pumping. The water level in this well ceased drawdown after 4 hours and remained at the same level until the end of the pump test, 11 hours and 45 minutes later. It is believed that either there is a fracture in the riser pipe in well # W-2 at 1.55 feet below the top of the riser, or that a leak occurs around this well through the clay layer into the aquifer.

Plots of this nature allow for the calculation of transmissivity (T) and hydraulic conductivity (K) using the Theim-Forchheimer equilibrium equations (U.S. Dept. of the Interior, 1977) under the following assumptions:

- The aquifer is homogeneous, isotropic, and of uniform thickness
- The discharging well penetrates and receives water through the entire thickess of the aquifer
- Coefficient of transmissivity or permeability (hydraulic conductivity) is constant at all times and at all locations
- Discharging has continued for a sufficient duration for the hydraulic system to reach a steady state
- Flow to the well is horizontal, radial, and laminar, and originates from a circular open water source with a fixed radius and elevation which surrounds the well
- Rate of discharge from the well is constant

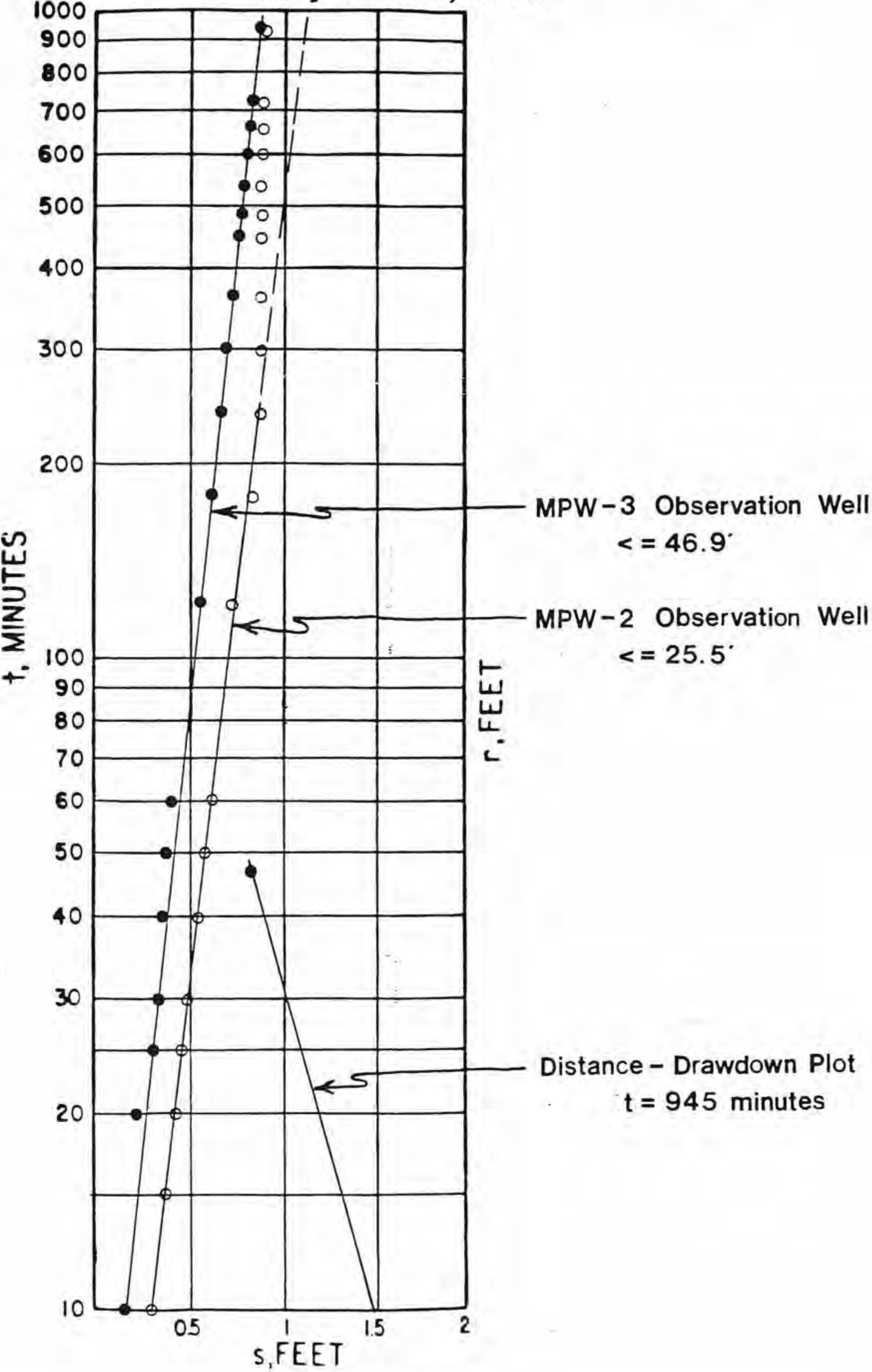
These equations are:

$$K = \frac{Q \log_e (r_3/r_2)}{2(3.14)M(s_2-s_3)}$$ for hydraulic conductivity, and

Monhegan Aquifer Characterization

Figure 3: Water Level Plot [Q = 7,200 gal / day]

May 29 - 30, 1990



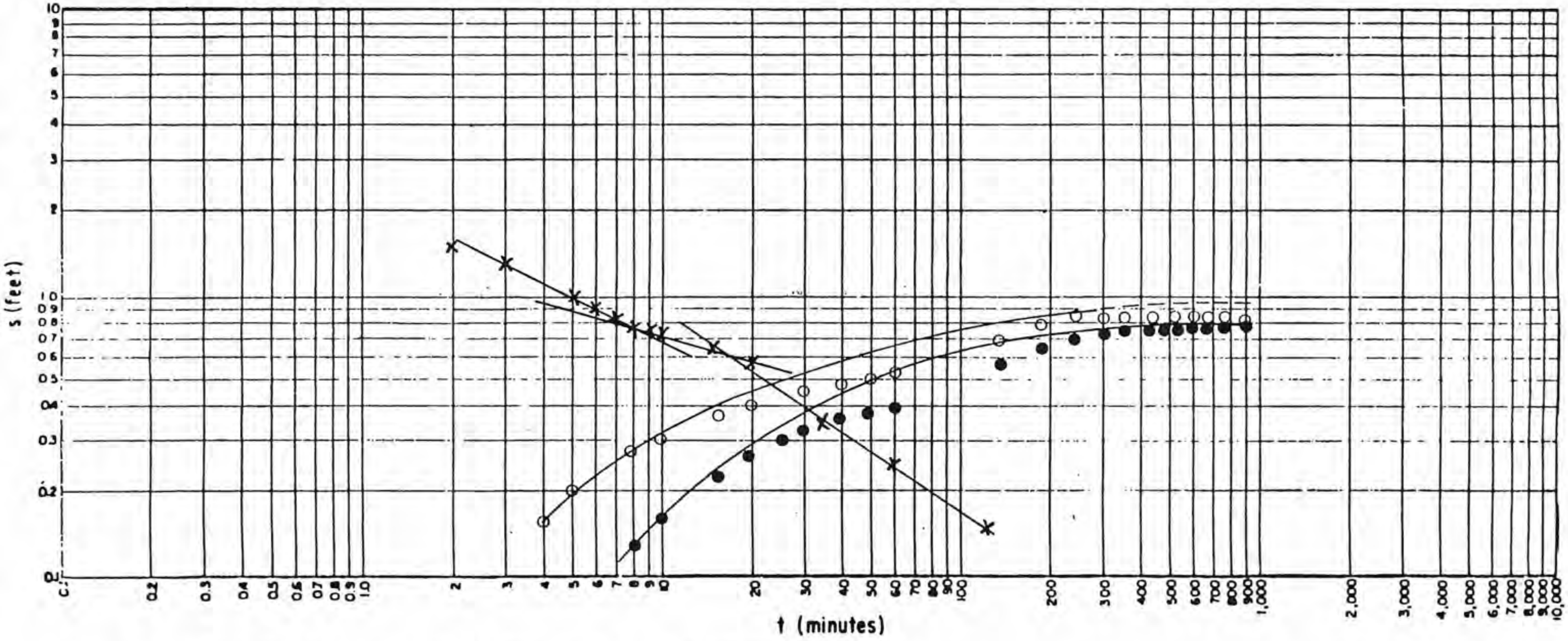
MPW-3 Observation Well
r = 46.9'

MPW-2 Observation Well
r = 25.5'

Distance - Drawdown Plot
t = 945 minutes

Monhegan Aquifer Characterization

Figure 4: Observation Well Drawdown Curves (Q= 7,200 gal/day)
May 29 – 30, 1990



○ **MPW–2 Observation Well (r = 25.5')**

● **MPW–3 Observation Well (r = 46.9')**

x **MPW–1 Recovery Curve (r = 0.0')**

$$T = \frac{Q \log_e (r_3/r_2)}{2(3.14)(s_2/s_3)}$$ for transmissivity, where

M = saturated thickness of the aquifer = 30'
Q = discharge of the test well = 7,200 gallons per day
s = drawdown in observation wells
r = distance from test wells

Solving these equations under the conditions given above, K = 57.2 gallons per day per square foot and T = 1,704 gallons per day per foot.

3.4 Discussion of Results Utilizing the Thiem-Forchheimer Equilibrium Method

There are several limitations to utilizing this method in determining the characteristics of an aquifer according the the U.S. Dept. of the Interior (1977).

Three criteria were utilized to determine the duration of the pump test. First, the pumping rate was below 25 gallons per minute. The U.S. Dept. of Interior (1977) recommends a pump test of 4 hours minimum duration for pump flow rates of less than 25 gallons per minute. Second, the pump test was continued until the rate of drawdown was less than or equal to 0.01 feet per hour. This criteria was met. Third, the pump test should be run such that the value of:

$u = r^2S/4Tt$, estimated for each hole is less than $0.1\ r^2/M$

This condition was met for both W-2 and W-3.

Other conditions should also be met (U.S. Dept. of Interior, 1977) for using the equilibrium method. First, it is assumed that the pumping well penetrates the entire aquifer and is screened for the entire interval. Given that this condition was impossible to meet on Monhegan because of the logistics and expense of installing such a well, it was not met. However, partial penetration of a confined aquifer is acceptable as long as drawdown measurements are taken from observation wells located at least 1.5 times the aquifer depth from the pumping well; and that the drawdown of the piezometric surface created at any of the wells does not intersect or penetrate the aquifer for confined aquifers. Both of these conditions were met during the pumping test.

Perhaps the largest limitation of utilizing the equilibrium method is that it does not adequately predict storativity especially where there are conditions of a leaky confined aquifer -- utilization of the transient method of determining the aquifer's characteristics should be used under these conditions (U.S. Dept. of Interior, 1977).

3.5 Distance - Drawdown Plot

The pump test data also allowed for Distance-Drawdown Plot to be determined (Figure 3). Extrapolation of this straight-line plot indicates that there will be no drawdown of the aquifer head at a distance of approximately 350' from a 2" diameter well pumping at a discharge rate of about 5 gallons per minute.

Since the Monhegan Water Company draws water from three to five active well points simultaneously, most within 100 feet of each other, undoubtedly each well point has a drawdown cone which intersects other active well points. This condition most likely results in a reduction of the pumping efficiency from each of the well points being pumped.

3.6 Determination of Aquifer Characteristics Using the Transient Method

Transient equations permit analysis of aquifer conditions that vary with time and involve storage. The assumptions underwhich the equations are based include:

- The aquifer is confined, horizontal, homogeneous, isotropic, of uniform thickness, and of infinite areal extent
- The pumping well is of infinitesimal diameter and fully penetrates the aquifer
- Flow to the well is radial, horizontal, and laminar
- All water comes from storage in the aquifer within the area of influence and is released from storage instantaneously with decline in pressure
- Transmissivity and storativity of the aquifer are constant in time and space

Theis (1935) provides a graphical method of solution that gives satisfactory results over using the tedious mathematical equations using a plot of drawdown (s) versus time (t) plotted on 3 x 5 cycle logarithmic graph paper (Figure 3).

Inspection of the plot, however, indicates that the drawdown curves for W-2 and W-3 indicate conditions other than those for an ideal confined aquifer. They indicate that there exists a condition of a change in storage over time by their "S" configuration and that the aquifer behaves as a "leaky" aquifer. To be more specific, the confining bed overlying the aquifer is the "leaking" bed (lake clay) and is, in turn, overlain by an unconfined aquifer (peat).

Glover, Moody, and Tapp (1954 and 1960) developed simplified methods of analysis using a family of type curves based on the Theis-type curve (Figure 5). By superimposing the family of curves over the plotted curves for each well, a curve value (x = 0.4) is determined and the transmissivity and storativity of the confined aquifer is determined by numerical equations, as is the vertical hydraulic conductivity of the overlying "leaking" confining layer.

Thus, T is calculated using the formula:

$$T = Qu/6.28s$$

K'/M' is calculated using the formula:

$$K'/M' = T\ (x/t)^2$$

S is calculated using the formula:

$$n = t\ (K'S/M')$$

when:

T = transmissivity of the aquifer in gallons per day per foot

K' = vertical hydraulic conductivity of the leaky confining bed above the aquifer

M' = saturated thickness of the leaking confining bed above the aquifer (30 feet)

S = storage of the aquifer (dimensionless)

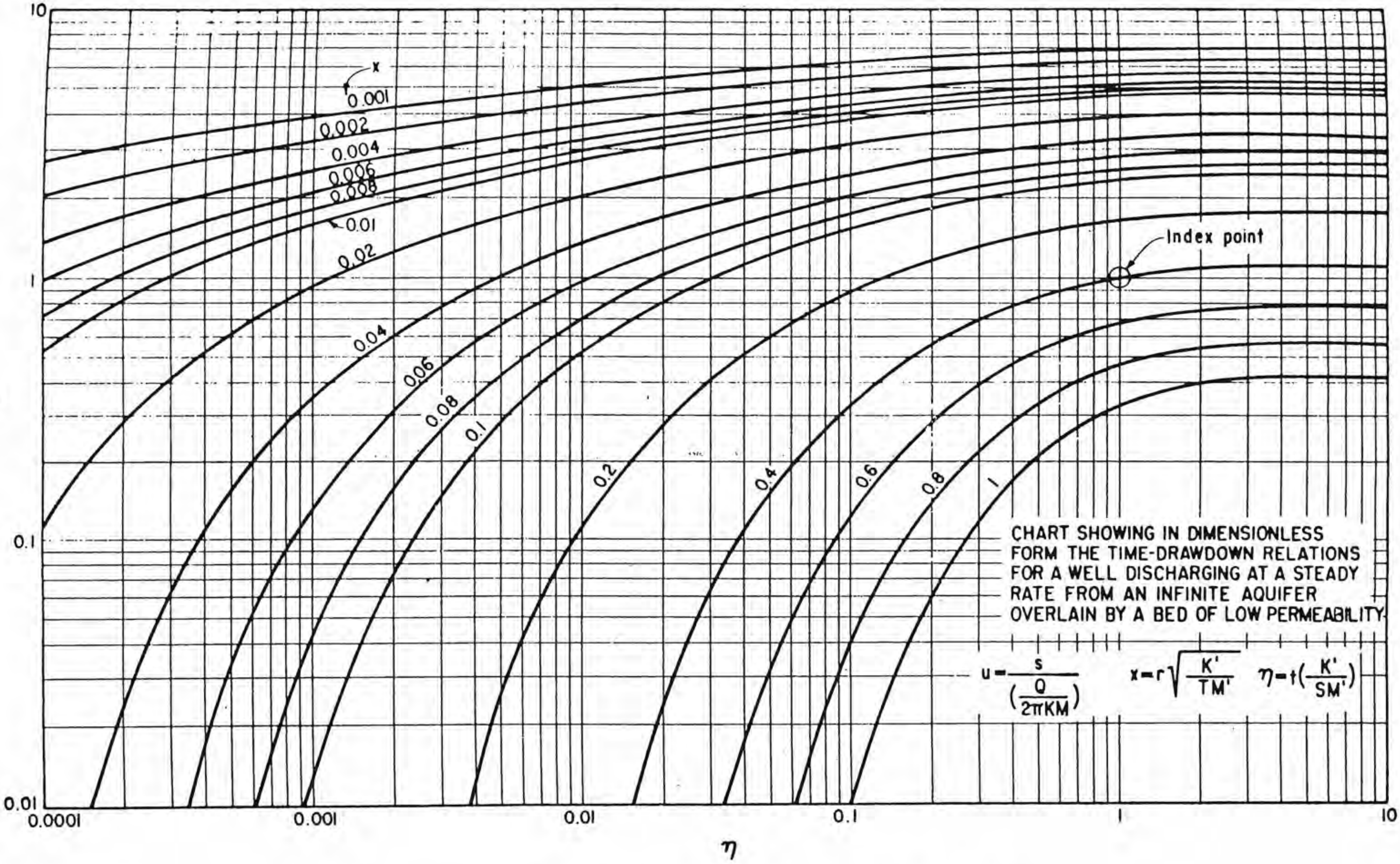


FIGURE 5 —Leaky aquifer type curves. 103–D–1438.

Solving these equations under the conditions above, the following values are found for the Monhegan Meadow aquifer, T equals 1850.9 gallons per day per foot; the vertical K' of the overlying confining bed is 3.2 gallons per day per square foot and S of the aquifer is .0074.

3.7 Discussion of Results Utilizing the Leaky Aquifer Solution Technique

Theoretically, utilization of the best solution technique for the determination of aquifer parameters yields a transmissivity for the aquifer which is 8.6% greater than the transmissivity determined from the equilibrium technique. This discrepancy is to be expected, as additional water volumes are being delivered to the pumping well from the leaky confining bed above.

The vertical hydraulic conductivity of the lake clay is about one-tenth the horizontal conductivity of the glacio-marine sand. K determined for the aquifer using the equilibrium technique is smaller than the K determined using the formula:

$$T = KM$$

using T as determined from the leaky aquifer solution and assuming that the depth of the saturated aquifer is approximately 30'. The determined K value for the aquifer is 61.7 gallons per day per square foot -- approximately 20 times that of the vertical conductivity of the lake clay. The K value for the aquifer falls in the mid-range of those values typical of silty sand (Freeze and Cherry, 1979) and of the low-end of clean sands.

The storativity, S, of the aquifer is a dimensionless parameter. Better termed as the storage coefficient of an aquifer, it can be described as that volume of water which an aquifer releases from storage per unit surface area of aquifer per unit decline in the component of hydraulic head normal to that surface. Storage coefficients range from .005 to .00005 in confined aquifers and from .01 to .30 in unconfined aquifers. The value found for the Monhegan aquifer lies between the ranges found in unconfined and confined aquifers and represents a condition of the aquifer which indicates that it is leaky, as discussed above.

3.8 Recovery Test

In order to provide some check on the pump test determination of aquifer transmissivity, a recovery test of water level was measured on the pump well, W-1, immediately after the pump test was stopped. The recovery test measured rising water levels in the pump well for a period of 2 hours after the pump test was completed (Appendix 1).

The water level changes were plotted vs. time on a 3 by 5-cycle log graph. From this curve, the resultant curve was divided into line segments and transmissivity determined using the formula:

$$T = 2.303Q/4(3.14)(s)$$

where s = change in water level over one log cycle (U.S. Dept. of Interior, 1977).

The transmissivity value determined by this method is 1782.9 gallons per day per foot, and compares favorably with the values determined using the drawdown data (1850.9 and 1,704 gallons per day per foot). The transmissivity determined by the recovery water level data is a measure of the transmissivity of the aquifer only in the very immediate area of the pumped well, whereas the previously determined values represent transmissivity of the aquifer deposit over the area of the well field and are much more characteristic of the aquifer as an integrated deposit.

3.9 Character of the Monhegan Aquifer

The pump test conducted on the aquifer has defined the aquifer as a "leaky" aquifer which derives additional water from the restrictive clay bed above the glacio-marine sand. Undoubtedly, but untested to date, ground water from unconfined late glacial stream deposits which overlie and are in contact with the glacio-marine sand at certain locations in the meadow also occurs. The pump test within the Monhegan well field, however, did not yield a cone-of-influence which would have converged on these deposits.

The transmissivity (1850.9 gallons per day per foot), hydraulic conductivity (61.7 gallons per day per square foot) and storativity (.0074) values determined for the aquifer are parameters of the aquifer and assist in evaluating the aquifer as a present and future public water supply.

The U.S. Dept. of Interior (1977) rates aquifers with a transmissivity of 10^3 gallons per foot per day as good for pumping domestic water supplies. Hydraulic conductivity values similar to those of the aquifer are rated as having a moderate to high permeability, typical of fine sands or silty medium to coarse sands.

The storativity value of the aquifer is between those typical of unconfined sand and gravel aquifers and confined aquifers. This situation is relatively beneficial given the circumstances of the Monhegan aquifer. Smaller values of storativity would indicate that greater pumping effort would have to be expended to lower the piezometric surface over a large area in order to deliver an adequate volume of water for consumption in relation to the pumping effort required to deliver the same amount of water from an unconfined aquifer. This has implications regarding contaminant time-of-travel distances from the Monhegan well head field and well-head protection management.

4.0 WATER QUALITY SAMPLING

4.1 Quality at the Well Field

Three water quality samples were taken from well W-1, one prior to initiating the pump test (MA-1) and a second just after the pump test (MA-2). The analyses establish the baseline water quality for the aquifer in the area of the Monhegan Water Company well field as well as the determination of any significant changes in water quality over time with increased volume withdrawal. A third sample (MA-3) was taken from the well on August 24, 1990, after almost a complete season of withdrawal from the aquifer.

The water samples, kept on ice and delivered to an analytical laboratory as soon as possible after sampling, were analyzed for the primary drinking water standards and selected secondary drinking water standards (Appendix 2).

The analyses and applicable drinking water standards are presented in Table 2:

TABLE 2

Water Quality Sample Analyses and Drinking Water Standards
Monhegan Aquifer Baseline Water Samples

PARAMETER	MA-1	MA-2	MA-3	STANDARD
Total Coliform Bacteria (Colonies per 100 ml)	1	*	27.0	1
Turbidity (NTU)	25.0	13.0	1.6	5**
Color (PCU)	<10	16	>70	15
Total Dissolved Solids (mg/l)	354	364	280	500
Odor (T.O. No.)	2	<2	<1	2
Hardness (mg/l $CaCO_3$)	200	244	191	Hard***
pH	8.3	7.6	7.9	-
Nitrate-nitrogen (mg/l)	0.585	0.504	ND	10.0
Chloride (mg/l)	20	16	38	250
Cadmium (mg/l)	0.002	0.004	ND	0.010
Lead (mg/l)	0.014	0.026	ND	0.050
Sodium (mg/l)	29.5	23.5	23	20.0
Copper (mg/l)	<0.02	0.06	0.05	1.0
Iron (mg/l)	0.37	1.64	0.92	0.3
Manganese (mg/l)	0.06	0.19	0.11	0.05
Zinc (mg/l)	1.33	0.74	0.26	5
Fluoride (mg/l)	0.101	0.053	ND	2.4

* Indicates probable contamination by improper handling during sampling.

** Applied only to surface water supplies.

*** No standard exists.

The water quality analyses indicate that the Monhegan aquifer water exceeds several primary and secondary drinking water standards. Standard parameters for which the aquifer water is well below minimum allowable concentrations are: fluoride, zinc, copper, lead, cadmium, Nitrate-nitrogen, total dissolved solids, and odor.

Parameters where minimum allowable concentrations of the Maine Primary and Secondary Drinking Water Standards (Maine Dept. of Human Services, 1983) are exceeded in one or both of the samples are discussed individually below.

Turbidity: The reported turbidity values are higher than usually allowed from a surface water body public water supply (Maine Dept. of Human Services, 1983). No guidelines are given for ground water supply origin. In all likelihood, the higher than acceptable turbidity readings come from suspended inorganic particulate matter (clays and silts) which occur naturally within the aquifer as well as the clay bed lying above the aquifer. In addition, iron precipitates may also add to the turbidity of the water.

The turbidity level of the water sample collected at the end of the summer season was well below the recommended standard. This reduction of turbidity may have resulted because the pumping wells developed their own filtration packs of aquifer sediments around each well screen after pumping was initiated. This likely occurred soon after the wells were pumped on a continuous basis. The turbidity of water delivered to the individual users on Monhegan is probably within acceptable limits as the suspended materials settle out of the water column after water is pumped to the two 17,500 gallon stainless steel standpipes on Lighthouse Hill for temporary storage.

Color: The level of color in the aquifer water is, again, attributable most likely to dissolved organics and suspended particulate matter in the natural waters, especially those in contact with the peat deposits overlying the aquifer sand. Since the iron content of the aquifer water is also high, much of the color imparted to the water may come from suspended iron particulates. The level of color is less than or just above the minimum acceptable level and does not constitute a health problem, although it could be a nuisance from time to time with regard to the staining of clothing during washings. The level of color from sample MA-3 well exceeds the minimum recommended level of the standards and is interpreted to result because, after a certain period of pumping from the aquifer, more and more water utilized from the aquifer is drawn more directly from the overlying clay and peat beds, as well as from surface water runoff entering the margins of the aquifer. These waters, having been in recent contact with decaying vegetation matter, most likely have higher levels of tannins and humic acids which impart a brown color to waters.

Hardness: There are no minimum acceptable levels of hardness. The levels of hardness reported in the analyses subjectively classifies the aquifer water as hard. This is attributable to the high shell content (calcium carbonate) of the glaciomarine sand aquifer. The hardness of the water can be overcome by using water softeners. Unfortunately, water softeners replace the calcium and magnesium found in the dissolved calcium carbonate with sodium, thus increasing the level of sodium in drinking water -- a constituent in the aquifer water which is already deemed as too high for blood pressure health purposes. Selective use of softeners for clothes and dishwashing by individual users, however, can overcome hardness problems without jeopardizing the sodium content of water used for cooking and drinking purposes.

Sodium: The levels of sodium in the aquifer water supply exceed, by less than 10 mg/l, the allowable minimum concentration for primary drinking water, but are less than the maximum concentration threshhold recommended for human consumption (40 mg/l)(Matthes, 1982). Individuals on doctor-recommended, low-sodium diets should restrict their consumption of the aquifer water, perhaps relying on bottled water for consumption and cooking.

A review of the general literature on ground water chemistry indicates that the source of this sodium is most likely sea salt in aerosols which fall out of the atmosphere during periods of fog, rain and snow on Monhegan -- therefore the level of sodium is most likely due to direct contribution from runoff which recharges the aquifer. Contributing to the direct recharge could also be connate marine waters now being leached from the glacio-marine clay deposits in the aquifer basin as well as the direct contribution of sodium leached from bedrock sources on the island. Although the levels of sodium are higher than allowed minimum concentrations, it should be noted that the levels of chloride in the aquifer do not indicate a condition of salt-water intrusion -- levels of chloride of 250 mg/l or more would indicate a definite trend towards the intrusion problem, but aquifer levels are an order of magnitude smaller than this threshhold condition.

Sodium analyses from 3 water quality samples collected along the margins of the aquifer indicated equivalent or higher levels occur at certain locations, further suggesting that the higher-than-recommended levels of this constituent are pervasive in island ground water, and most likely the result of aerosol precipitation.

Iron and Manganese: The levels of these two constituents commonly mimic one another in natural waters due to their similar origins and chemical behaviour. Manganese always occurs in lower concentrations than iron because of its lower relative abundance in rocks and soils (Matthes, 1982). The Monhegan aquifer contains levels of these two chemicals which are slightly higher than minimum allowable concentrations. Iron and manganese are derived from the direct chemical breakdown of the basic igneous rocks and soils of the islands and are carried by runoff to the reducing environment of the meadow bog. Both metals are highly soluable under reducing conditions and immediately precipitate out as hydroxides upon contact with atmospheric oxygen. At the concentrations which occur in the aquifer, they constitute more of a nuisance factor than a health hazard by increasing the turbidity and color of the water.

4.2 Water Quality from the Aquifer Margin

In order to determine if the margins of the aquifer are presently threatened by poorer quality shallow ground water or recharging stream water, a series of monitoring wells were installed along the western and southern margin of the aquifer. Three monitoring wells were installed along the southwest margin of the meadow (MMW-1, MMW-2 and MMW-3) where both shallow ground water from neighboring septic systems and stream water from a heavily-contaminated surface stream recharge the margin of the aquifer. An additional three wells were installed along the western margin of the aquifer (MMW-4, MMW-5 and MMW-6) directly down-gradient from several septic system leachfields to intercept shallow ground water entering the aquifer along this area (Plate 1)(Core logs from these well installations are provided as Appendix 3).

All 6 aquifer margin wells were installed on July 26, 1990. Wells were installed in vibra-core holes which remained open after removal of the corer with core. Immediately after installation, each well was developed by hand pumping the well dry or by the removal of at least 3 well volumes of water. The wells were left in place for almost a month prior to sampling. This allowed the

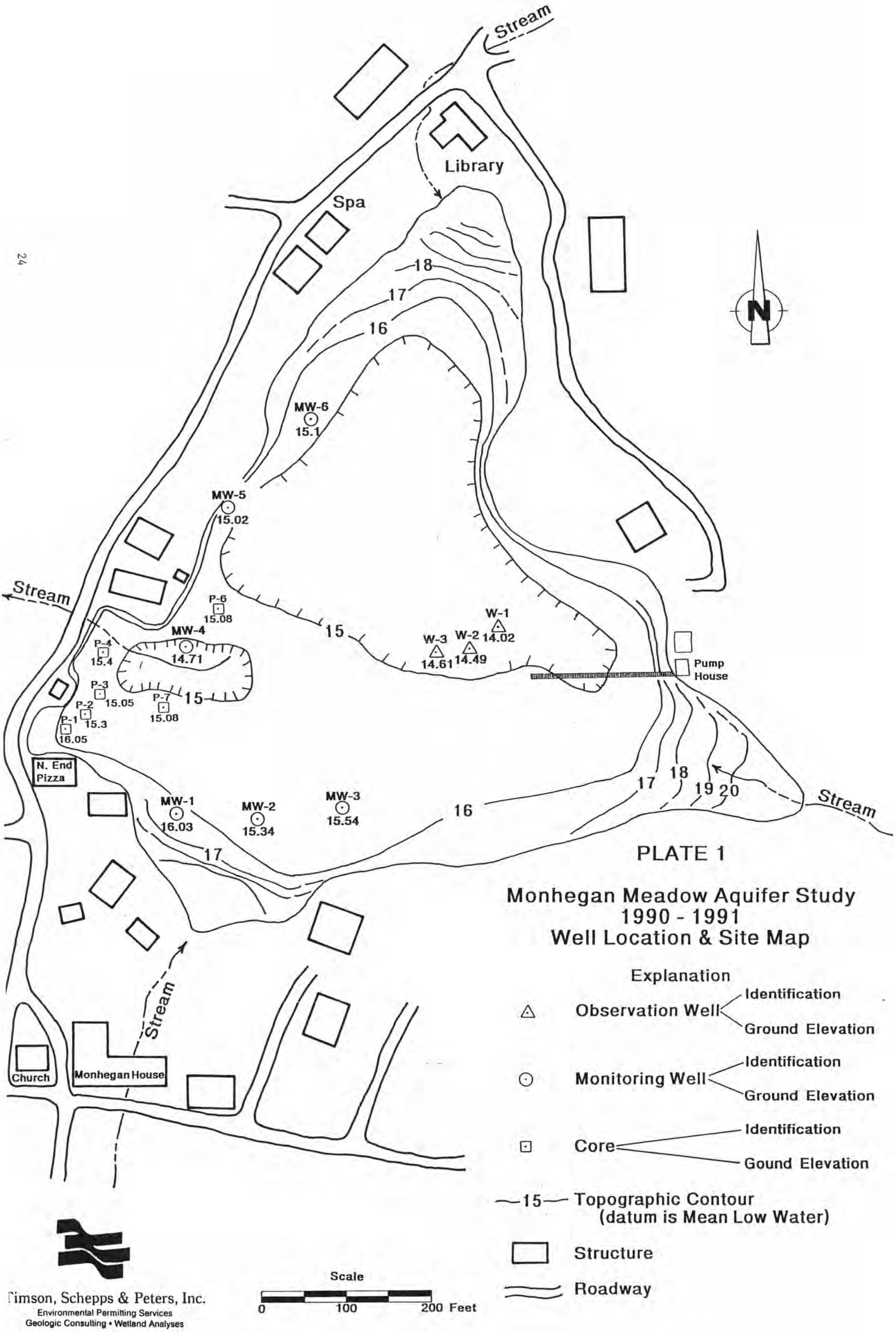


PLATE 1

Monhegan Meadow Aquifer Study
1990 - 1991
Well Location & Site Map

imson, Schepps & Peters, Inc.
Environmental Permitting Services
Geologic Consulting • Wetland Analyses

peat to close about each well riser and ensured equilibration of the well with ambient ground water conditions. All wells were sampled on August 24, 1990, using a teflon bailer. Approximately 1 hour prior to sampling, each well was again developed with the removal of all water within the well or by the removal of at least 3 well volumes. The teflon bailer was rinsed with distilled water prior to each sampling. Water samples were collected and immediately stored in a cooler with ice. All samples were delivered to a certified water analytical laboratory within 24 hours of sampling.

Water samples were collected from Wells MMW-1 and MMW-3 and analyzed for limited parameters (Nitrate-nitrogen and coliform bacteria), while a water sample from Well MMW-2 was analyzed for all primary drinking water standards. These analyses, from wells along the southern margin of the aquifer and at the foot of a stream entering the meadow, are presented in Appendix 4 and summarized in the following table:

TABLE 3

Water Quality Sample Analyses and Drinking Water Standards Southern Aquifer Margin

PARAMETER	MMW-1	MMW-2	MMW-3	STANDARD
Total Coliform Bacteria (Colonies per 100 ml)	120	0	40	1
Nitrate-nitrogen (mg/l)	<.20	<.20	<.20	10.0
Cadmium (mg/l)	-	<0.002	-	0.010
Lead (mg/l)	-	<0.005	-	0.050
Sodium (mg/l)	-	23	-	20.0
Arsenic (mg/l)	-	<0.005	-	0.050
Barium (mg/l)	-	0.005	-	1.0
Chromium (mg/l)	-	<.01	-	0.050
Mercury (mg/l)	-	<.001	-	0.002
Selenium (mg/l)	-	0.010	-	0.010
Silver (mg/l)	-	<.01	-	0.050

\- Analysis not conducted for this constituent.

Water samples were also collected from 3 wells located along the western margin of the aquifer (MMW-4, MMW-5, MMW-6) to determine if any subsurface septic leachate was effecting the water quality along this margin. All three wells were located downgradient of known subsurface sewage systems. Water quality samples from these three wells are presented in Appendix 4 and summarized in the following table:

TABLE 4

Water Quality Sample Analyses and Drinking Water Standards Western Aquifer Margin

PARAMETER	MMW-4	MMW-5	MMW-6	STANDARD
Total Coliform Bacteria (Colonies per 100 ml)	2	10	3	1
Nitrate-nitrogen (mg/l)	<.20	<.20	<.20	10.0
Cadmium (mg/l)	<0.002	<0.002	<0.002	0.010
Lead (mg/l)	<0.005	<0.005	<0.005	0.050
Sodium (mg/l)	24	32	36	20.0
Arsenic (mg/l)	<0.005	0.014	<0.005	0.050
Barium (mg/l)	0.019	0.018	0.015	1.0
Chromium (mg/l)	<.01	<.01	<.01	0.050
Mercury (mg/l)	<.001	<.001	<.001	0.002
Selenium (mg/l)	<0.005	<0.005	<0.005	0.010
Silver (mg/l)	<.01	<.01	<.01	0.050

Of note is the absence of elevated Nitrate (NO^3) nitrogen levels in any of the samples collected at the margins of the aquifer as well as the absence of or presence only of low levels of coliform bacteria. Elevated levels of either of these constituents would be indicative of inadequately-treated effluent from subsurface sewerage systems.

The lack of elevated Nitrate-nitrogen or high numbers of coliform bacteria colonies can possibly be attributed to several factors. First, shallow ground water as well as surface stream waters must flow into and through peat deposits before entering the aquifer deposit beneath the peat. All probe, boring and core information gathered from the margins of the meadow indicate that peat deposits overlap up onto whichever upland soil or ledge they are adjacent to. The partially decomposed and macerated vegetation matter of the peat deposits act as effective absorbants and filters for Nitrate-nitrogen, as well as bacteria (Baudo et.al., 1990). The stream which flows into the southern margin of the aquifer flows for about 100 feet on the surface, in and among rocks and gravel across a moderate slope which is also heavily vegetated. This allows for the water to be well oxygenated, thereby encouraging the swift demise of anaerobic bacteria and viruses. Well MMW-2 was installed in the stream delta deposits of this stream and found to penetrate a rapidly flowing and recharging shallow ground water regime. The water sample from this well contained no colonies of coliform bacteria, although the stream which feeds this area is known to be highly contaminated from neighboring up-gradient, poorly-maintained subsurface sewerage system leachfields.

Four of the 6 water samples (MMW-2, MMW-4 through MMW-6) were analyzed for sodium presence and concentration. Sodium levels ranged from 23 to 36 mg/l, providing further evidence that the sodium levels in the aquifer originate from atmospheric aerosols and precipitation, rather than from direct salt-water intrusion.

On the basis of these 6 samples, it appears that there is little threat to the water quality of the aquifer from surface stream runoff or shallow ground water recharge to the margins of the aquifer, at least along the southern and western margins.

5.0 STRATIGRAPHIC RELATIONSHIPS ALONG THE SOUTHWEST PORTION OF THE AQUIFER

Previous stratigraphic studies of the "Meadow" aquifer have determined the stratigraphy and three-dimensional relationship of the glacio-marine aquifer deposit with to the overlying lacustrine and palustrine deposits (Timson, 1989). Data for extending an interpretation of these relationships toward the southwest margin of the meadow, however, was lacking. Furthermore, the presence of definite shallow marine organism whole-shell remains found at the base of one vibra-core (MMW-6) clearly suggested that an open inlet existed between the meadow and the ocean (Monhegan Harbor) at the time the aquifer was initially deposited.

In order to determine the geometric limits and relationships of the meadow deposits in the southwest corner of this wetland, several borings and vibra-cores (P-1 through P-7) were taken in this area (Plate 1)(Appendix 3) on August 23, 1990). Investigations were concentrated in two areas -- landward of Fish

Beach and landward of Swim Beach -- areas suspected of being former inlets between the ocean and the meadow basin, primarily because they represent the only outcroppings of relatively thick coarse sand deposits in the general vicinity of the meadow.

One and one-half inch diameter borings (P-1 through P-3) were placed along the margins of the meadow landward of Fish Beach. These borings penetrated relatively short intervals of peat (4' to 7') before refusal at ledge or prior to penetrating a thin glacio-marine sand (1' thick) lying above bedrock.

Borings P-4 through P-7 were located landward of Swim Beach, and also in the vicinity of a stream which passes beneath the village road via a culvert and flows across the beach to empty into the harbor. These borings penetrated deeper intervals of peat before refusal in buried logs or to such a point where the limits of the boring auger or vibra-core were met. Several borings were attempted on the upper portions of Swim Beach, but the presence of numerous beach cobbles prevented any appreciable depth penetration.

Based upon the information gained from these borings, cores, and previous hydraulic borings from previous investigations (Timson, 1989) it is highly possible that an inlet between the harbor and the meadow in the location of Swim Beach during the deglaciation of Monhegan when sea levels were higher than present. As sea level lowered below the lip of bedrock which extends between Fish and Swim Beaches, wave activity reworked coarse glacial lodgement tills, ablation tills, and former shallow marine sands and gravels to form a short barrier beach and overwash at the narrow inlet opening. Initially, the barrier would most likely be breached often, during times of heavy spring rains which would allow the meadow basin to fill with water and overflow accross the low barrier. Storms, accompanied by higher than usual tides, could also have breached this low, thin barrier.

As sea level continued to lower, however, breaching of the barrier became less frequent and storm overwash deposits constructed the narrow beach ridge higher and higher. Further lowering of sea level continued to isolate the harbor from opean ocean waters, thereby preventing high storm waves from breaching the barrier from the ocean side.

Eventually, the meadow basin was an isolated brackish basin which would fill each spring with runoff to form a large pond. Periodically, the outfall stream would penetrate the barrier under strong freshet conditions. Perhaps, the meadow basin became completely isolated as sea level continued to lower, with fresh water escaping only as shallow ground water penetrating the beach and washover gravels of Swim Beach, until man inhabited the island and found it advantageous from time to time to drain the meadow by constructing a permanent channel across the upper portions of Swim Beach. The large number of logs encountered in the peat deposit just landward of Swim Beach certainly suggest that the meadow existed as an open and relatively deep pond for a period of time, with pond drainage directed toward, perhaps, an ephemeral inlet. Logs, floating in the pond, would become lodged near the inlet shallows and eventually become buried with peat as the pond filled to capacity with land-derived sediments and wetland vegetation took over after pond filling. The crest of the beach ridge became the convenient land bridge between the northern and southern parts of the village after the island was inhabited.

Of interest regarding this matter is a 1900 geologic map of the island by E.C.E. Lord which shows the existing stream entering the eastern margin of the meadow to exist accross the entire width of the meadow to empty into the harbor at Swim Beach. The present outlet stream maintains a definite channel only for about 40' from the Swim Beach culvert, then loses its identity toward the middle of the meadow. There is no defined stream channel in the meadow along its eastern margin, although a 3' wide channel empties into the meadow at this location.

Regardless of its post-glacial history, the "Meadow" aquifer deposit is interpreted to be in direct contact with the beach and overwash deposits which make up Fish Beach; and is, therefore, in direct hydrogeologic contact with marine water (Figure 6). Only the difference in hydraulic head and the density difference between fresh and salt-water maintain the interface along the outer seaward face of Swim Beach.

6.0 DISCUSSION: AQUIFER WATER QUALITY AND HYDRAULIC CHARACTER

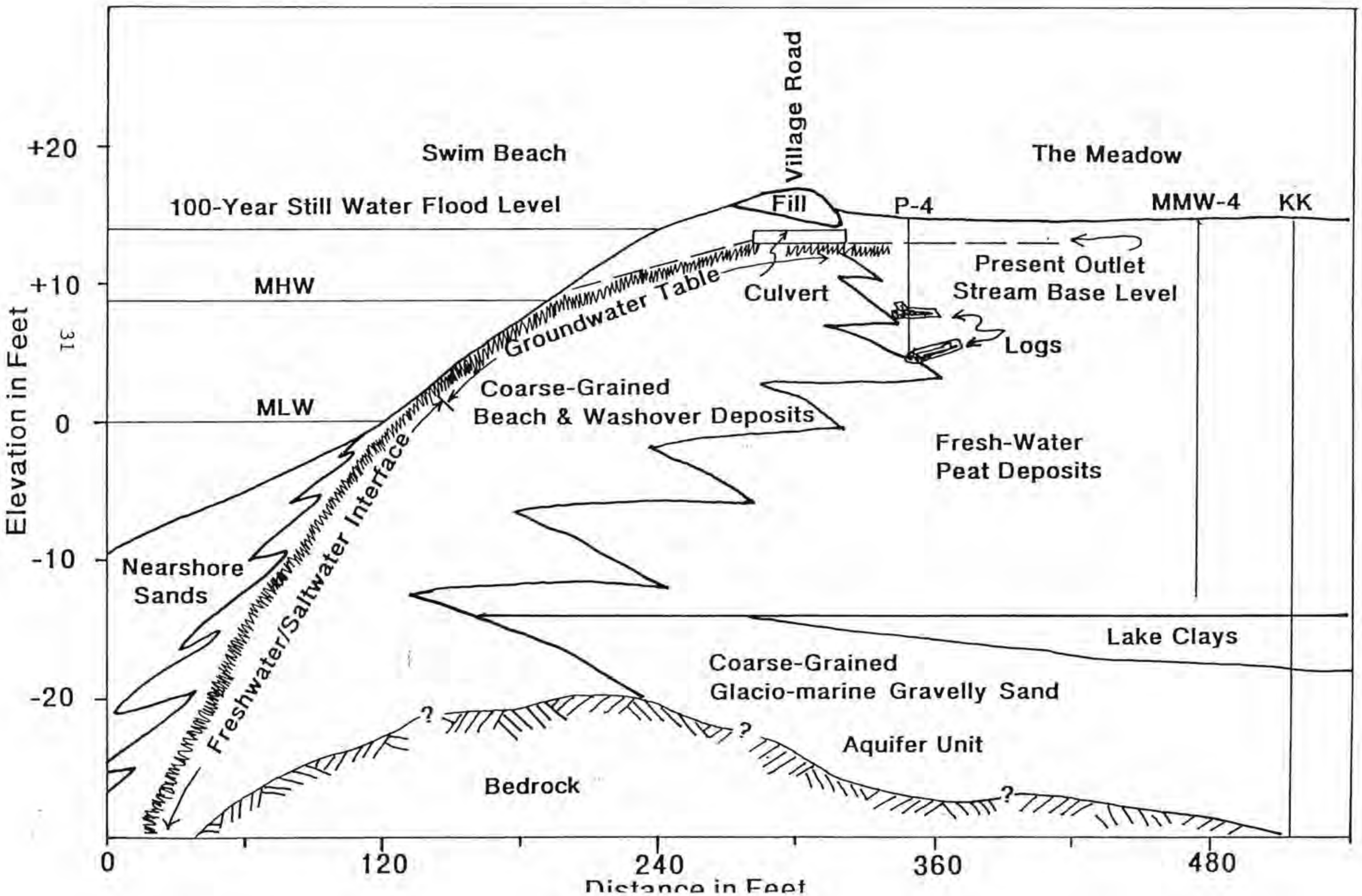
6.1 Aquifer Water Quality at the Monhegan Water Company Well Field

Water quality samples from well points penetrating the Monhegan aquifer indicate that the quality of the aquifer water is relatively high. Those constituents of the water which exceed the primary and secondary drinking water standards are constituents which most likely can be accounted for as originating naturally within the surface and ground water hydrogeochemical cycle of the

Stratigraphic Interpretation

Monhegan Aquifer/Swim Beach Deposit Hydrogeologic Interface

Figure: 6



island's setting.

There is little to no evidence, at this time, that the aquifer waters in the area of the Monhegan Water Company well field are degraded due to human interference or causes. Several indicators verify this conclusion:

- Levels of Nitrate-nitrogen: The levels of Nitrate-nitrogen found in the aquifer water are equivalent to values known for background precipitation in Maine (Tewhey, 1987). They do not indicate any increase above background due to subsurface sewerage treatment effluent within the drainage basin of the aquifer.

- Levels of chloride: Chlorides in the aquifer ground water are far below those expected even for the lowest level of salt-water intrusion. While the choride level in the water sample taken at the end of the summer season increased over the previous two, the elevated level is still far below that of chloride expected because of salt-water intrusion. Furthermore, the level of sodium found in the third sample was no higher than found in the previous samples -- a further indication that continuous pumping in the existing well field over a summer season does not induce salt-water intrusion into the well field area.

- Levels of iron and manganese: The levels are low -- a general indication of absence polluted ground water.

- Bacteria levels: Acceptable numbers of fecal coliform bacteria colonies are present per 100 ml of water. One water sample was most likely contaminated during collection. The presence of fecal coliform bacteria, itself, is not harmful to health, but serves to indicate the likelihood that other, more harmful, pathogenic bacteria and viruses could be present. Elevated coliform bacteria levels were found in the water sample collected at the end of the season, but these levels are still relatively low.

6.2 Water Quality at the Margins of the Aquifer

Water quality samples taken from the south and west margins of the aquifer indicate that there is little threat to the aquifer water supply from surrounding subsurface sewerage leachate or surface stream pollutants. While shallow ground waters and surface waters which enter the meadow basin may well be contaminated beyond Maine Primary Drinking Water Standards, it is believed that the peat deposits which overlie the aquifer effectively filtrate these waters to remove harmful bacteria and viruses. It has also been documented that peat acts as an effective filtration and absorbant media for Nitrate-nitrogen.

The present active well system has a cone of radius which extends to include all of the southern margin of the aquifer and almost to the northwest margin where water samples were collected from. The only documented water quality effect of directly utilizing water from these margin areas might be a small increase in the levels of coliform bacteria at the well head. Chorination of the water, however, removes any threat to human health from this condition.

6.3 Threat of Salt-Water Intrusion from Swim Beach

The aquifer sand deposits are most likely in direct contact with ocean water at an interface located at Swim Beach. Swim Beach is interpreted to be an outcrop of the aquifer, itself. The head and density differential between the aquifer water and marine water prevents the intrusion of salt water into the aquifer.

The cone of influence of the active Monhegan Water Company well field has been determined to be approximately 350 feet from the outermost active well point pumping water from the aquifer. The edge of the cone of influence, therefore, is approximately 200 feet from the upper intertidal zone of Swim Beach. It does not appear that salt-water intrusion is a problem with respect to the present withdrawal rates and position of the active pumping wells within the aquifer.

6.4 Implications for Improvements to the Present Well Field

Timson (1989) suggested that moving the present well field further to the west to allow for deeper penetration of active well points into the aquifer might increase the efficiency of the present active well points. While the present well points are located in the aquifer where the aquifer unit is only 9' to 15' thick, placement of well points approximately 100' further west would allow for penetration of about 40' to 50' into the aquifer unit, allowing for the withdrawal of deeper aquifer water supplies, unavailable to the present system.

As a result of this investigation, this suggestion appears to have partial merit. There appears to be little threat from utilizing aquifer water from the western margin of the aquifer with respect to water quality -- placement of one or two well points 100 feet further to the west from their present position would not result in a significant threat to the quality of the water supply from marginal aquifer waters or salt-water intrusion from the Swim Beach area. Furthermore, separation of one or several well points to greater distances from one another will decrease the cone-of-radius interference between each well.

The water quality threat, however, will remain low only if the same well conditions are maintained, i.e. maintaining the same diameter well point. Increasing the diameter of any well point which is placed deeper into the aquifer will increase the cone-of-radius influence, thus drawing water from within the aquifer from distances greater than 350 feet. A greater threat of water quality degradation from salt-water intrusion will result.

Should one well point be moved further west from the present well field, it is suggested that it be limited to one well point, of no greater than 2 inches in diameter, and that this well be sampled monthly for water quality testing, especially levels of sodium and chloride, during its first full season of use.

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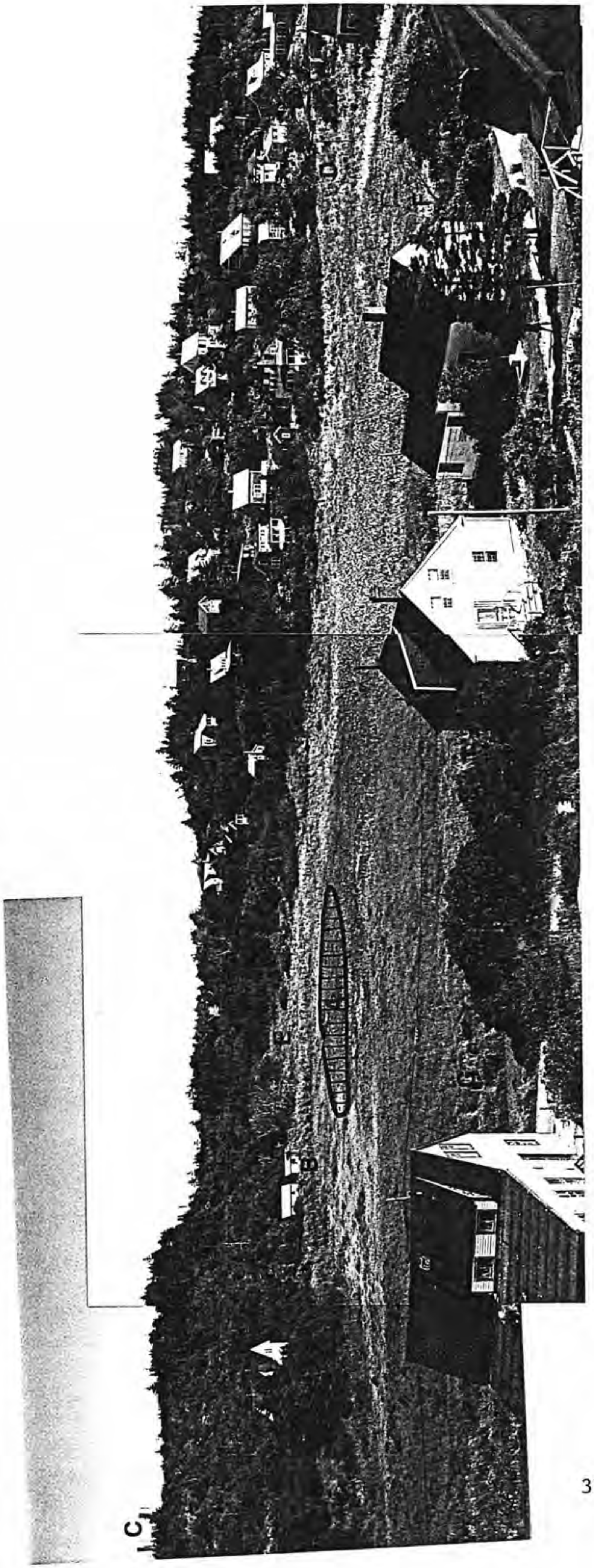
PHOTOGRAPHIC PLATE A

A view of the Monhegan "Meadow" looking southeasterly. A = the area of the meadow where the Monhegan Water Company maintains an active well field penetrating the meadow wetland peat deposits and into the glacio-marine sand aquifer unit below. B = well pump house. C = Water Company storage tanks. D = stream delta into the meadow. E = stream delta into the meadow. F = location of the outlet stream from the meadow.


C
B
A
E
D

APPENDIX 1

Pump Test Data

MONHEGAN AQUIFER STUDY

PUMP TEST

WELL DESIGNATION: MPW-1 RECOVERY TEST

DATE: MAY 31, 1990

DEPTH OF WELL: 36.3'

WELL DIAMETER: 1 7/8"

WELL ELEVATION:

PUMP RATE:

TIME BEGIN TEST: 7:51, MAY 31, 1990

TIME END TEST: 9:51, MAY 31, 1990

TIME INTERVAL: **DEPTH TO WATER LEVEL:**

0 MINUTE:
1 MINUTE: 1.69'
1.5 MINUTES:
2 MINUTES: 1.48'
2.5 MINUTES:
3.0 MINUTES: 1.29'
4 MINUTES: 1.13'
5 MINUTES: 1.0'
6 MINUTES: .86'
8 MINUTES: .78'
10 MINUTES: .71'
11 MINUTES: .68'
12 MINUTES: .66'
13 MINUTES: .65'
30 MINUTES:

40 MINUTES:
50 MINUTES:
1 HOUR:
2 HOURS:
3 HOURS:
4 HOURS:
5 HOURS:
6 HOURS:
7 HOURS:
8 HOURS:
9 HOURS:
10 HOURS:
11 HOURS:
12 HOURS:

RECOVERY
15 MIN: .63'
20 MIN: .55'
1 HR: .26'
2 HR: .16'
3 HR:
4 HR:
5 HR:
6 HR:
7 HR:
8 HR:
9 HR:
10 HR:

MONHEGAN AQUIFER STUDY

PUMP TEST

WELL DESIGNATION: MPW-2 LOCATION IS 25.47' FROM MPW-1

DATE: MAY 30, 1990 DEPTH OF WELL IS 51'

WELL DIAMETER: 1 7/8" **WELL ELEVATION:** **PUMP RATE:** 5 GAL./MINUTE

TIME BEGIN TEST: 15:34

TIME END TEST: 7:51, MAY 31, 1990

TIME INTERVAL: **DEPTH TO WATER LEVEL:**

0 MIN: .70'
1 MINUTE: .72'
1.5 MINUTES: .74'
2 MINUTES: .77'
2.5 MINUTES: .80'
3.25 MINUTES: .83'
4 MINUTES: .85'
5 MINUTES: .90'
6.5 MINUTES: .95'
8 MINUTES: .97'
10 MINUTES: 1.0'
15 MINUTES: 1.07'
20 MINUTES: 1.10'
25 MINUTES: 1.13'
30 MINUTES: 1.15'

40 MINUTES: 1.17'
50 MINUTES: 1.20'
1 HOUR: 1.32'
2 HOURS: 1.40'
3 HOURS: 1.50'
4 HOURS: 1.55'
5 HOURS: "
6 HOURS: "
7 HOURS: "
8 HOURS: "
9 HOURS: "
10 HOURS: "
11 HOURS: "
12 HOURS: "

15:46 HOURS: 1.55'

RECOVERY
15 MIN:
30 MIN:
1 HR:
2 HR:
3 HR:
4 HR:
5 HR:
6 HR:
7 HR:
8 HR:
9 HR:
10 HR:

MONHEGAN AQUIFER STUDY

PUMP TEST

WELL DESIGNATION: MPW-3 LOCATION IS 47.0' FROM MPW-1

DATE: MAY 30, 1990 DEPTH OF WELL IS 46.9'

WELL DIAMETER: 1 7/8"	**WELL ELEVATION:**	**PUMP RATE:**
TIME BEGIN TEST:	**TIME END TEST:**	5 GAL./MINUTE
15:34	7:51, MAY 31, 1990	

TIME INTERVAL:	**DEPTH TO WATER LEVEL:**	
0 MIN: .90'		
1 MINUTE:	**40 MINUTES:** 1.25'	RECOVERY
1.5 MINUTES:	**50 MINUTES:** 1.27'	15 MIN:
2 MINUTES: .94'	**1 HOUR:** 1.3'	30 MIN:
2.5 MINUTES:	**2 HOURS:** 1.47'	1 HR:
3.25 MINUTES:	**3 HOURS:** 1.55'	2 HR:
4 MINUTES: .97'	**4 HOURS:** 1.60'	3 HR:
5 MINUTES: 1.0'	**5 HOURS:** 1.62'	4 HR:
6.5 MINUTES: 1.025'	**6 HOURS:** 1.64'	5 HR:
8 MINUTES: 1.06'	**7 HOURS:** 1.655'	6 HR:
10 MINUTES: 1.13'	**8 HOURS:** 1.67'	7 HR:
15 MINUTES: 1.17'	**9 HOURS:** 1.68'	8 HR:
20 MINUTES: 1.20'	**10 HOURS:** 1.69'	9 HR:
25 MINUTES: 1.22'	**11 HOURS:** 1.70'	10 HR:
30 MINUTES: 1.15'	**12 HOURS:** 1.71'	

15:46 HOURS: 1.72'

APPENDIX 2

Water Quality Analyses from the Pump Test Well

P.O. Box 400 (Rte. 115)
North Windham, Maine 04062
207-892-4485

MCFARLAND ASSOCIATES, INC.
ANALYTICAL LABORATORY
WATER SPECIALISTS

Office Hours
8:00 AM to 4:00 PM
Mon. - Fri.

LAB.REF.NO.: 37917
BOTTLE NO.: T

CLIENT: NAME: Timson Schepps & Peters Inc
ADDRESS: 103 Water Street Hallowell, Maine 04347
TELEPHONE: 623-0053

WELL LOCATION: NAME OR LOT NO.: Monhegan Island
ADDRESS: Map 1

DESCRIPTION: DEPTH: - TYPE: -

DATE & TIME: COLLECTION: 5/31/90 1100 COLLECTED BY: client
ARRIVAL: 6/1/90 0940 BOTTLES BY: T
EXAMINATION: 6/1/90 1600 EXAM BY: JPB/MSM/BBB

BACTERIA: TOTAL COLIFORMS: 1 (COLONIES PER 100ml)

PHYSICAL: COLOR: < 10 (PCU) ODOR: 2 (T.O. NO.)
TURBIDITY: 25.0 (NTU) HARDNESS: 200 (mg/L $CaCO_3$)
TOTAL DISSOLVED SOLIDS: 351 (mg/L)

CHEMICAL: pH: 8.3
AMMONIA-N: - (mg/L) COPPER: < 0.02 (mg/L)
NITRATE-N: 0.585 " IRON: 0.37 "
NITRITE-N: - " MANGANESE: 0.06 "
CHLORIDE: 20 " CHLORINE: "
CADMIUM: 0.002 ZINC: 1.33
LEAD: 0.014 FLUORIDE: 0.101
SODIUM: 29.5

COMMENTS: EXCELLENT( ) SATISFACTORY( ) SATISFACTORY WITH NOTATIONS(x^2)$^{\& 3}$
UNDESIRABLE( ) UNSATISFACTORY(x^1) INCOMPLETE( )

(1) Excess turbidity See note # 2
Suggest turbidity sediment filter
(2) Excess iron and manganese See note # 7
(3) Excess Sodium See attached form

STATE CERTIFIED ACCEPTED BY FmHA - HUD - VA

< = Less than
> = Greater than

1. COLIFORM GROUP BACTERIA

SIGNIFICANCE

The coliform group bacteria includes organisms found in the intestinal tracts of warm-blooded animals, birds, decaying organic matter (hay, leaves, wood, etc.) the top 2 to 3 feet of the soil, lakes, ponds, brooks, rivers, drainage and types of vegetables.

Because the organisms can cause some illness; because the presence of coliform organisms in the water suggests that other, more harmful, organisms may be present; water containing more than one coliform group bacteria per 100 ml of sample should not be used for drinking or cooking purposes unless boiled for 5 minutes or disinfected by other means.

DUG WELL

* SAME PROCEDURE FOR DRILLED WELL – USE 4 OUNCES FOR EVERY 10 FEET OF WATER, CHLORINE TABLETS FOR A WELL OVER 400 FEET.

A dug well should have a water-tight lining such as clay tile, concrete tile or concrete to a depth of at least ten (10) feet below the ground surface (a stone lining permits the entrance of moles, woodchucks and surface water). The joints between tiles and holes around water pipes must be sealed and the top of the well should extend 2-3 feet above the surrounding ground surface. The area around the well should be built up for drainage and ditches should be provided to collect and carry-off any surface water that might collect around the well. The well should be provided with a concrete or metal cover that fits down over the outside edge of the well tile. There should be no opening through the cover (unless it is constructed and sealed to prevent the entrance of water, small animals and/or their droppings, etc.) and the cover should have a "drip-edge".

Whenever the well, pump or water piping is opened, repaired or altered, the water system should be disinfected. This can be accomplished by mixing chlorine bleach (clorox, dazzle, etc.) with the water in the well (the recommended dosage can be found in the table below). Once the chlorine solution has been mixed with the well water, open all the faucets, sill-cocks and similar outlets until the odor of chlorine is noted. Then allow the mixture to stand in the system for a few hours. The chlorine mixture should then be flushed from the system using an outside sill-cock and a garden hose. Before submitting a sample of water for analysis, let the water run from the sample faucet for 10 minutes before taking sample and test by smelling to insure that there is no odor of chlorine present.

NOTE: All lake, stream or pond waters used for drinking purposes need to be continuously and efficiently disinfected.

RECOMMENDED CHLORINE DOSAGES USING 5.25% CHLORINE BLEACH

DIAMETER OF WELL	DOSAGE FOR EACH TEN FEET OF DEPTH
2"	½ oz.
4"	2 oz.
6"	4 oz.
8"	7 oz.
12"	1 pint
24"	2 quarts
36"	1 gallon
48"	2 gallons
60"	3 gallons
72"	4 gallons
96"	8 gallons

* PLEASE NOTE :
8 HOURS OF CONTACT TIME (CLOROX TO WATER) WHILE IN WELL IS NECESSARY BEFORE RUNNING WATER INTO LINES.

8 ounces = 1 cup

2. TURBIDITY, COLOR AND ODOR

SIGNIFICANCE

Although these tests do not directly measure the safety of the water, they do relate to an individual's acceptance of a water. The levels of 5 units of turbidity, 15 units or color, and odor number of 3 are levels which are objectionable to a number of people.

POSSIBLE CORRECTIVE MEASURES

Turbidity and color may be removed by entanglement with a chemical floc, setting, and infiltration. Activated carbon cartridges will remove tastes and odors be adsorption.

If a supply suddenly develops an offensive odor, discontinue using the water for drinking and cooking purposes until another analysis shows the water is satisfactory for such purposes.

3. CHLORIDES

SIGNIFICANCE

Chlorides in normal ground waters fall in the 1 to 2 milligram per liter (mg/L) range, and in reasonable concentrations, are not harmful to humans. Concentrations of 250 mg per liter of Chloride and above give a salty taste to water which is objectionable to many people, and are judged unsatisfactory.

POSSIBLE CORRECTIVE MEASURES

Chlorides may enter ground water from a variety of sources such as natural mineral deposits, sea water infiltration of subterranean water supplies, highways, kitchen and other household waste-water. Concentrations over 20 mg/L suggest the presence of one of the above sources of salt.

One should attempt to locate and eliminate the sources of chlorides and hope that in time the water will return to its natural state. Chloride removal equipment capable of treating 5 to 10 gallons per day is available for home use, and we suggest you check with a water treatment specialist.

4. NITROGEN COMPOUNDS

SIGNIFICANCE

The compounds of nitrogen are of great interest because of the importance of nitrogen in the life processes of all plants and animals. The nitrate, nitrite and ammonia determinations are of particular interest in identifying possible sources and age of pollution.

NITRATE: Nitrates, in high concentrations, can and do cause methemoglobinemia or so called nitrate poisoning in infants. Supplies with 10 or more mg of N/L are judged unsatisfactory and are not considered safe for drinking or cooking. It is especially dangerous to children and should never be used in infants formulas.

NITRITE: Nitrite in water poses a greater health hazard, but fortunately it seldom occurs in high concentrations. Waters with nitrite-nitrogen concentrations over 1mg/L should not be used for infant feeding.

POSSIBLE CORRECTIVE MEASURES

Nitrogen compounds result from drainage from privies, private sewage disposal systems, manure piles, gardens, heavily fertilized land or similar sources of pollution. Once the source of pollution is located and removed, the waters may take a number of years to return to normal.

Nitrate removal equipment is available for home use, and we suggest you check with a water treatment specialist.

5. HARDNESS

SIGNIFICANCE

Hard waters are as satisfactory for human consumption as soft waters. But because of their adverse action with soap, and their tendency to produce scale in hot-water pipes, heaters, etc., it may be desirable, from the economics standpoint to install a domestic water softener.

Waters nationwide are classified as follows:

0-75 mg/L of calcium carbonate	Soft
75-150 mg/L of calcium carbonate	Moderately hard
150-300 mg/L of calcium carbonate	Hard
300-up mg/L of calcium carbonate	Very hard

POSSIBLE CORRECTIVE MEASURES

The hardness in water is derived largely from calcium and magnesium dissolved from the soil and rock formations and may be removed by one of several methods - precipitation, ion exchange or a combination.

6. COPPER

SIGNIFICANCE

In-as-much as copper is an essential and beneficial element in human metabolism and does not constitute a health hazard but does impart an undesirable taste to water when present in concentrations of 1 to 5 milligrams per liter (mg/L), waters are judged undesirable at 1.0 mg/L.

POSSIBLE CORRECTIVE MEASURES

Since copper is not naturally found in Maine's ground waters, but is introduced when acid waters come in contact with copper pipes, this is best eliminated with pH control equipment or changing to plastic pipe.

7. IRON AND MANGANESE

SIGNIFICANCE

Both iron and manganese are highly objectionable constituents in domestic water supplies. Iron and manganese impart a brownish color to laundered goods and can appreciably effect the taste of beverages, including coffee or tea.

Waters with a combined concentration of iron and manganese greater than 0.3 milligrams per liter are considered undesirable.

POSSIBLE CORRECTIVE MEASURES

There are a number of domestic iron and manganese removal units commercially available from water treatment specialists.

8. DETERGENTS

SIGNIFICANCE

A positive detergent test suggests a poorly constructed and/or located private sewage disposal unit which if not corrected may result in a grossly contaminated water supply.

9. SWIMMING ANALYSIS

The sample submitted is satisfactory for swimming purposes as long as conditions remain the same.

10. OLD SAMPLES

Water samples arriving at the laboratory 30 hours or more after the sampling time will not give a true representation of the bacterial quality of the water and will be reported without bacteriological analysis

11. MISCELLANEOUS

Water bottles which are received without the information portion of the form completed, cannot be properly interpreted and will not be interpreted

P.O. Box 400 (Rte. 115)
North Windham, Maine 04062
207-892-4485

Office Hours
8:00 AM to 4:00 PM
Mon. - Fri.

McFARLAND ASSOCIATES, INC.
ANALYTICAL LABORATORY
WATER SPECIALISTS

LAB.REF.NO.: 37917
BOTTLE NO.: T

CLIENT: NAME: Timson Schepps & Peters Inc.
ADDRESS: 103 Water Street Hallowell, Maine 04347
TELEPHONE: 623-0053

WELL LOCATION: NAME OR LOT NO.: Monhegan Island
ADDRESS: Map 2

DESCRIPTION: DEPTH: - TYPE: -

DATE & TIME: COLLECTION: 5/31/90 1100 COLLECTED BY: client
ARRIVAL: 6/1/90 0940 BOTTLES BY: T
EXAMINATION: 6/1/90 1600 EXAM BY: JPB/MSM/BBB

BACTERIA: TOTAL COLIFORMS: CG* (COLONIES PER 100ml)

PHYSICAL: COLOR: 16 (PCU) ODOR: < 2 (T.O. NO.)
TURBIDITY: 13.0 (NTU) HARDNESS: 244 (mg/L $CaCO_3$)
TOTAL DISSOLVED SOLIDS: 364 (mg/L)

CHEMICAL: pH: 7.6
AMMONIA-N: - (mg/L) COPPER: 0.06 (mg/L)
NITRATE-N: 0.504 " IRON: 1.64 "
NITRITE-N: - " MANGANESE: 0.19 "
CHLORIDE: 16 " CHLORINE: - "
CADMIUM: 0.004 ZINC: 0.74
LEAD: 0.026 FLUORIDE: 0.053
SODIUM: 23.5

COMMENTS: EXCELLENT( ) SATISFACTORY( ) SATISFACTORY WITH NOTATIONS(x)$^{3 \& 4}$
UNDESIRABLE( ) UNSATISFACTORY(x^{1})$^{\& 2}$ INCOMPLETE( )
(1) Excess bacteria See note # 1
Suggest chlorination and retest for bacteria * Confluent Growth
(2) Excess turbidity See note # 2 Suggest Turb. sediment filter
(3) Excess iron and manganese See note # 7
(4) Excess sodium See attached form

STATE CERTIFIED ACCEPTED BY FmHA - HUD - VA

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APPENDIX 3

Geologic Logs of Cores and Borings in the Meadow

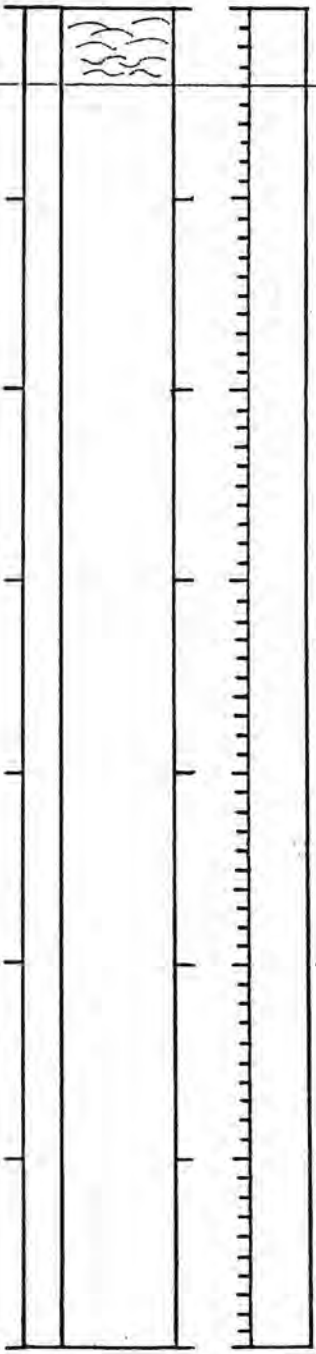
Timson, Schepps & Peters, Inc.

Environmental Permitting Services
Geologic Consulting • Wetland Analyses
P.O. Box 150, Hallowell, Maine 04347

PROJECT: Monhegan Aquifer Study
Project No. Monhegan-2
Hole No. P-1

Logged By: Barry S. Timson
Date: 8/23/90 **Page** 1 **of** 1
Location: N of Northend Pizza
Elevation: ~16.07 **Depth:** 4.0'
Contractor: TSP Inc
Equipment: 1"-Diam Auger

DEPTH	DESCRIPTION	Dip	GRAPHIC LOG Struc.	GRAPHIC LOG Comp.	WELL DETAIL	Notes
0'	Peat (fibrous/reed sedge)					
	Refusal (ledge)					
10'						



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Environmental Permitting Services
Geologic Consulting • Wetland Analyses
P.O. Box 150, Hallowell, Maine 04347

PROJECT: Monhegan Aquifer Study

Project No. Monhegan-2

Hole No. P-2

Logged By: Barry S. Timson

Date: 8/23/90 **Page** 1 **of** 1

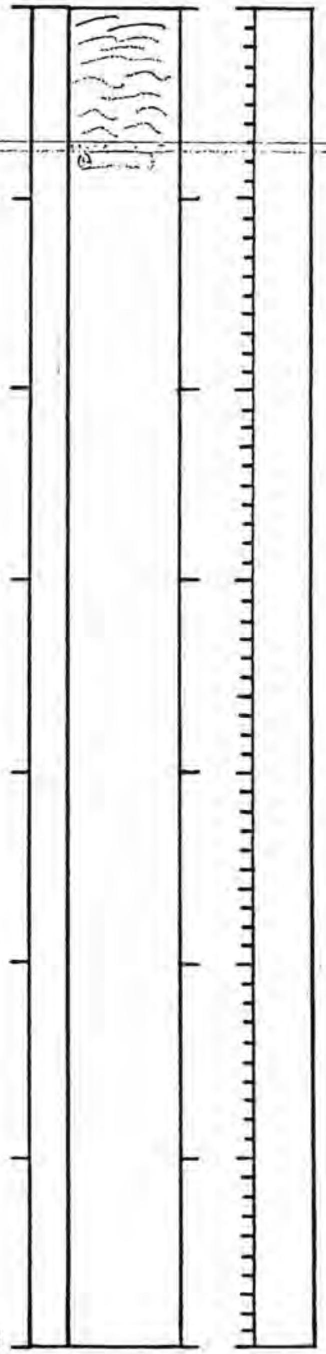
Location: SE of Fish House

Elevation: ~15.33' **Depth:** 7.5'

Contractor: TSP, Inc

Equipment: 3"-Diam Vibra-core

DEPTH	DESCRIPTION	Dip	GRAPHIC LOG Struc. Comp.	WELL DETAIL	Notes
0'	Fibrous over Reed Sedge Peat				
	Coarse Sand				
	Refusal (Log)				
10'					



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P.O. Box 150, Hallowell, Maine 04347

PROJECT: Monhegan Aquifer Study

Project No. Monhegan-2

Hole No. P-3

Logged By: Barry S. Timson

Date: 8/23/90 **Page** 1 **of** 1

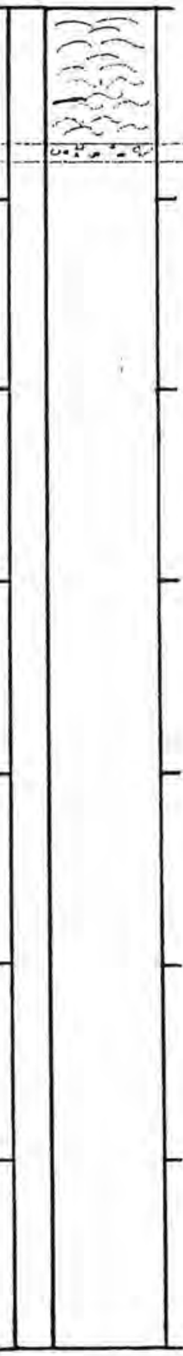
Location: E of Fish House

Elevation: +15.25 **Depth:** 8.0'

Contractor: TSP. Inc.

Equipment: 3" Diam. Vibra-Core

DEPTH	DESCRIPTION	Dip	GRAPHIC LOG Struc.	GRAPHIC LOG Comp.	WELL DETAIL	Notes
0	Fibrous over Reed/ Sedge Peat					
	Coarse Sand					
10'	Refusal (unknown)					



3-4

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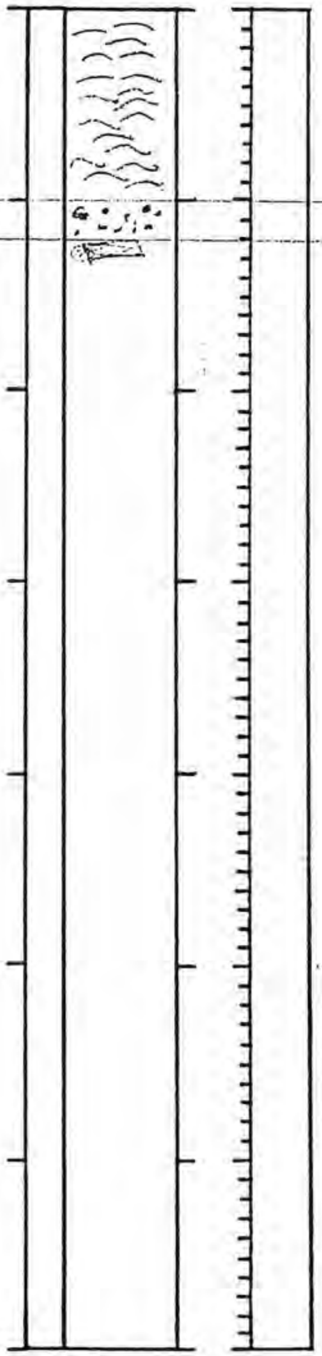
PROJECT: Monhegan Aquifer Study
Project No. Monhegan-2
Hole No. P-4

Logged By: Barry S. Timson
Date: 8/23/90 Page 1 of 1
Location: N of Fish House (Outlet Brook)
Elevation: +75.4' Depth: 12'
Contractor: TSP, Inc
Equipment: 3"-Diam Vibra-Core

DEPTH	DESCRIPTION	GRAPHIC LOG Dip Struc. Comp.	WELL DETAIL	Notes
0'	Fibrous over Reed/Sedge Peat			
10'	Coarse, grey sand			
	Refusal in Log			
20'				



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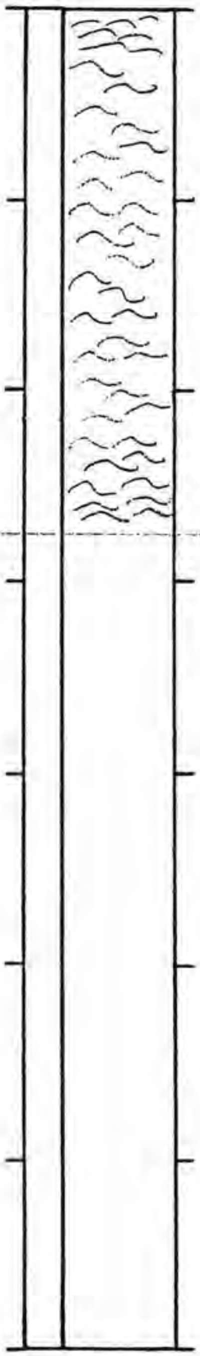
PROJECT: Monhegan Aquifer Study
Project No. Monhegan-2
Hole No. P-5
Logged By: Barry S. Timson
Date: 8/23/90 **Page** 1 **of** 1
Location: MMW-4 well
Elevation: 44.71' **Depth:** 27.5'
Contractor: TSP, Inc.
Equipment: 3" Diam Vibra-core

DEPTH	DESCRIPTION	Dip	GRAPHIC LOG Struc. Comp.	WELL DETAIL	Notes
0'					
10'	Thin Fibrous Peat layer over Reed Sedge Peat				
20'					
30'	Max Length of Vibra-Core				



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PROJECT: Monhegan Aquifer Study

Project No. Monhegan-2

Hole No. P-6

Logged By: Barry S. Timson

Date: 8/23/90 **Page** 1 **of** 1

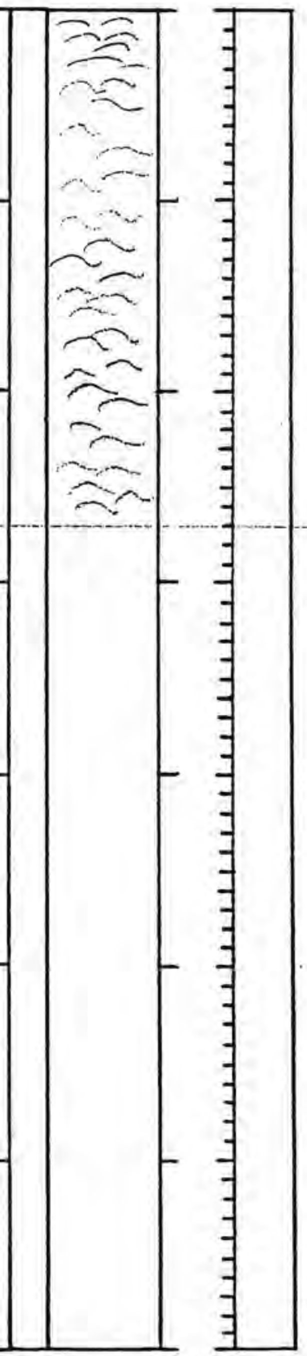
Location: E of V. Ward House

Elevation: +15.08' **Depth:** 27'

Contractor: TSP, Inc.

Equipment: 3"- Diam Vibra-Core

DEPTH	DESCRIPTION	Dip	GRAPHIC LOG Struc. Comp.	WELL DETAIL	Notes
0					
10'	Fibrous Peat over Reed/Sedge Peat				
20'					
30'	Limit of Vibra-core				



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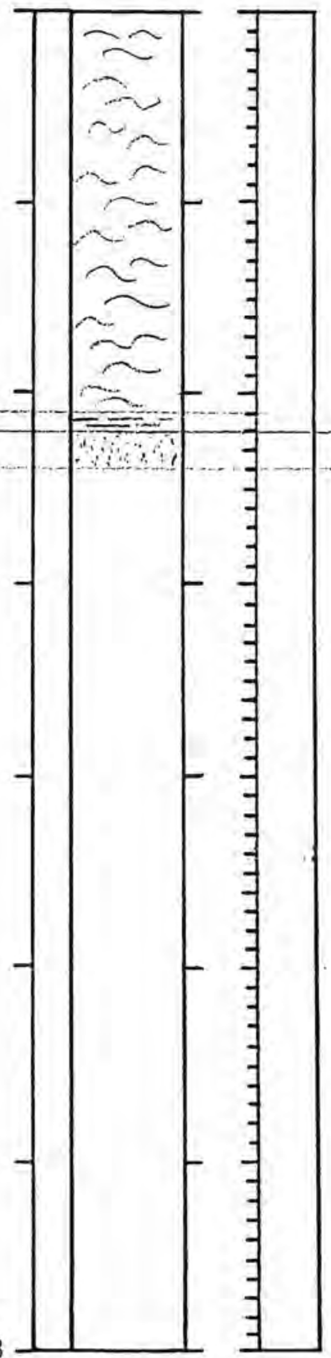
PROJECT: Monhegan Aquifer Study
Project No. Monhegan-2
Hole No. P-7

Logged By: Barry S. Timson
Date: 8/23/90 **Page** 1 **of** 1
Location: E. of White House
Elevation: +/15.08 **Depth:** 24.5'
Contractor: TSP Inc.
Equipment: 2" Diam Vibracore

DEPTH	DESCRIPTION	Dip	GRAPHIC LOG Struc. Comp.	WELL DETAIL	Notes
0					
	Reed/Sedge Peat				
10'					
20'					
	Grey Brown Lake Clay				
	Grey Sand @ Shell				
	Refusal @ 24.5'				
30'					



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PROJECT: Monhegan Aquifer Study

Project No. Monhegan-2

Hole No. MMW-1

Logged By: Barry S. Timson

Date: 7/26/90 **Page** 1 **of** 1

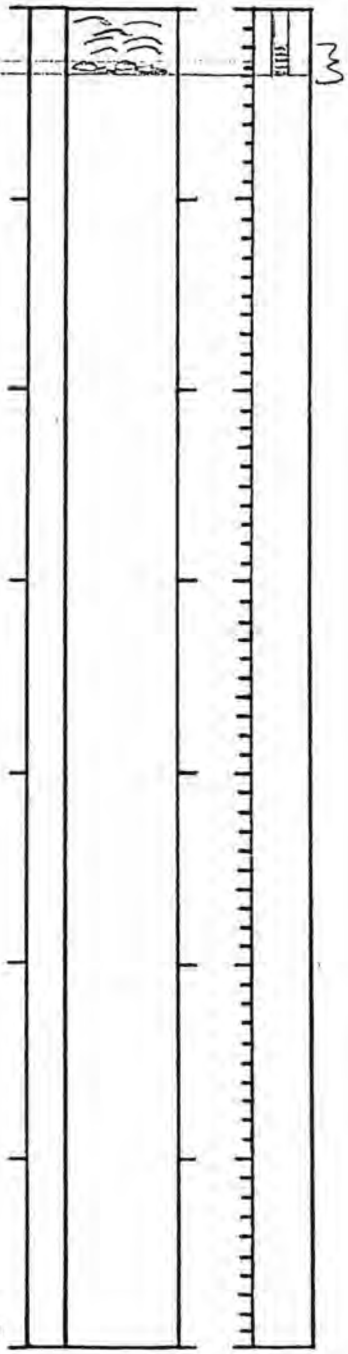
Location: Monhegan House Stream Delta

Elevation: +4.03 **Depth:** 3.2'

Contractor: TSP Inc.

Equipment: 3"-Diam Vibra-core

DEPTH	DESCRIPTION	Dip	GRAPHIC LOG Struc.	GRAPHIC LOG Comp.	WELL DETAIL	Notes
0	Fibrous Peat					Riser
	Stream Gravel					Screen (010")
	Refusal					
10'						



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PROJECT: Monhegan Aquifer Study

Project No. Monhegan-2

Hole No. MMW-2

Logged By: Barry S. Timson

Date: 7/2[illegible]/00 **Page** 1 **of** 1

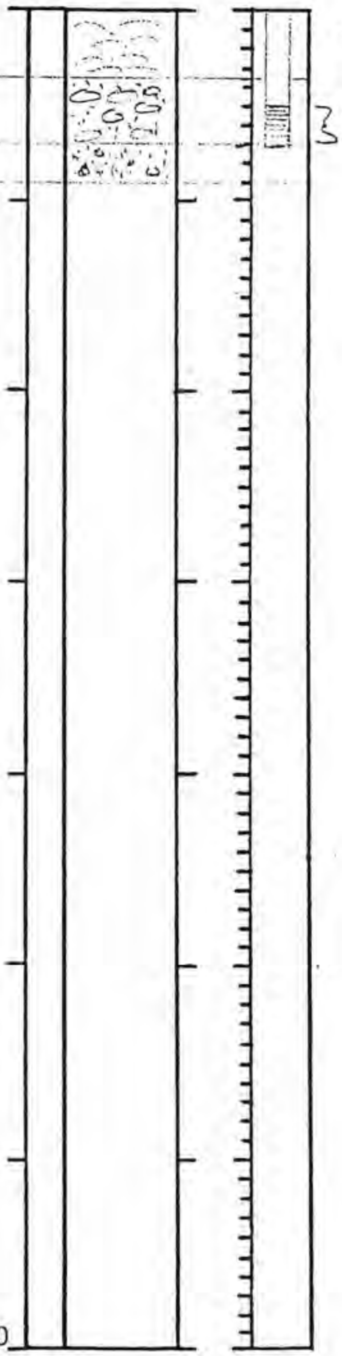
Location: Monhegan House Stream Delta

Elevation: +/15.34 **Depth:** 9'

Contractor: TSP. Inc.

Equipment: 3"-Diam Vibra-core

DEPTH	DESCRIPTION	Dip	GRAPHIC LOG Struc. Comp.	WELL DETAIL	Notes
0'	Fibrous Peat				Riser
	Gravelly, Coarse grey sand				Screen
	Pebbly, Coarse-medium sand				
10'	Refusal				



3-10

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PROJECT: Monhegan Aquifer Study

Project No. Monhegan - 2

Hole No. MMW-3

Logged By: Barry S. Timson

Date: 7/26/90 **Page** 1 **of** 1

Location: Monhegan Inn Stream - C. Martin

Elevation: +15.54 **Depth:** 3'

Contractor: TSP, Inc.

Equipment: 3" Diam Vibra-core

DEPTH	DESCRIPTION	Dip	GRAPHIC LOG Struc. Comp.	WELL DETAIL	Notes
0'	Peat				Riser
	Till (brown)				Screen
	Refusal				
10'					

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PROJECT: Monhegan Aquifer Study

Project No. Monhegan-2

Hole No. MMW-4

Logged By: Barry S. Timson

Date: 7/26/90 **Page** 1 **of** 1

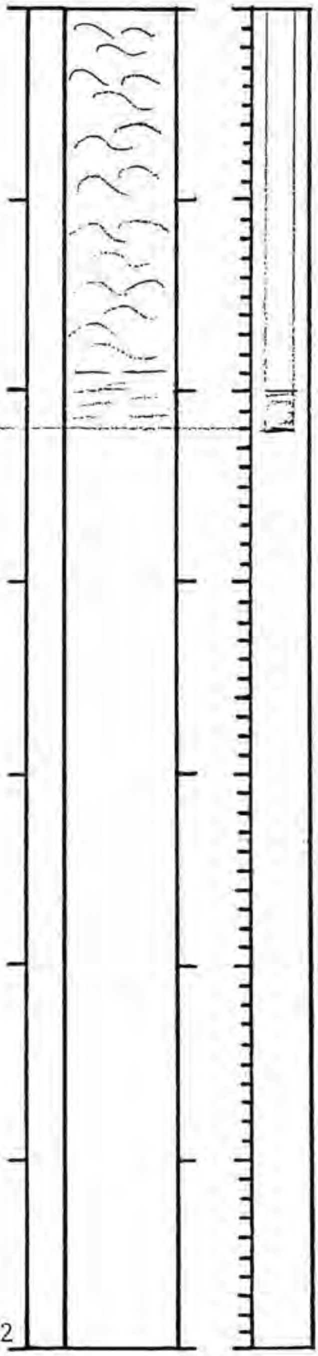
Location: Near Outlet Brook

Elevation: +14.71 **Depth:** 22'

Contractor: TSP Inc.

Equipment: 3"-Diam Vibra-core

DEPTH	DESCRIPTION	GRAPHIC LOG Dip Struc. Comp.	WELL DETAIL	Notes
0'	Reed/sedge Peat and Sedimentary Peat			
10'				Riser
20'				Screen



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Environmental Permitting Services
Geologic Consulting • Wetland Analyses
P.O. Box 150, Hallowell, Maine 04347

PROJECT: Monhegan Aquifer Study

Project No. Monhegan-2

Hole No. MMW-5

Logged By: Barry S. Timson

Date: 7/26/90 **Page** 1 **of** 1

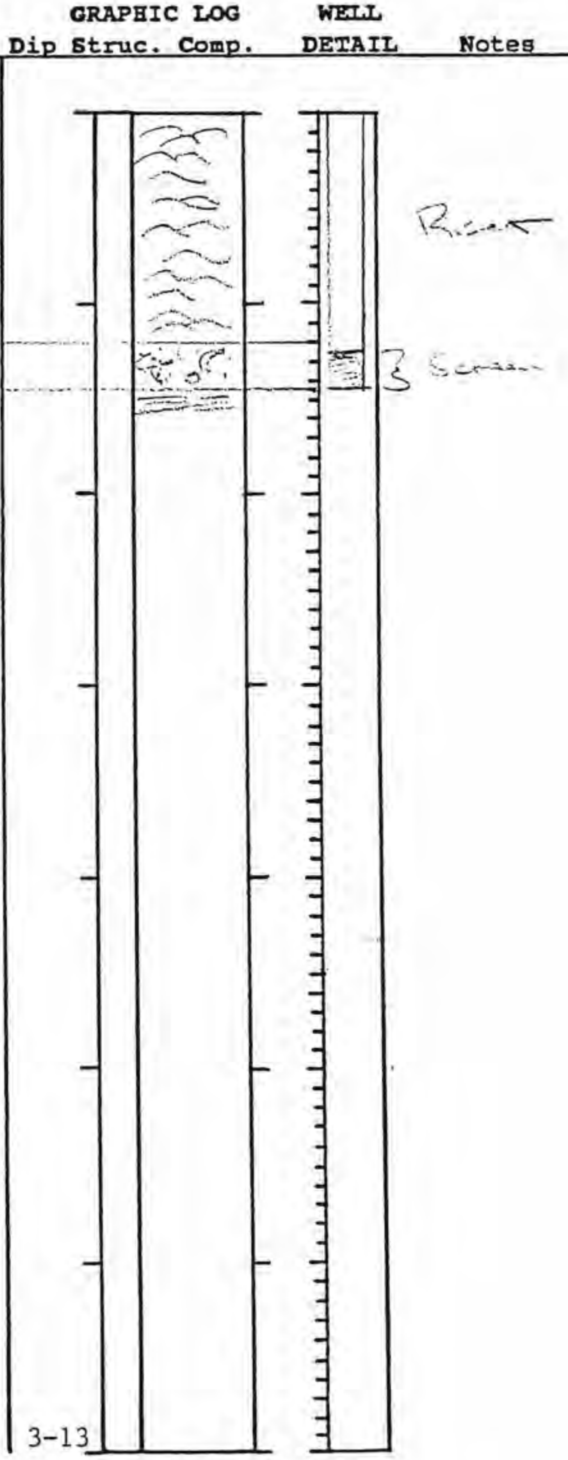
Location: NE of V. Lord House

Elevation: +15.02 **Depth:** 14.6'

Contractor: TSP Inc

Equipment: 3"-Diam Vibra-core

DEPTH	DESCRIPTION
0'	Fibrous over Reed/Sedge Peat
10'	Gravelly coarse Sand @ Shells
	Glacio-marine Clay Refusal @ 14.6'
20'	



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P.O. Box 150, Hallowell, Maine 04347

PROJECT: Monhegan Aquifer Study

Project No. Monhegan-2

Hole No. MMW-6

Logged By: Barry S. Timson

Date: 7/27/90 **Page** 1 **of** 1

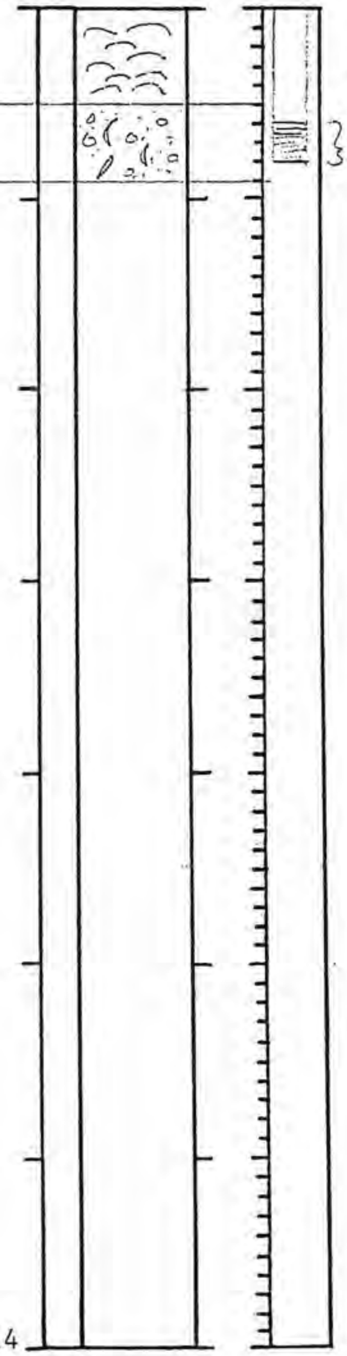
Location: E. of Z. Brackett House

Elevation: +15.1 **Depth:** 9'

Contractor: TSP, Inc.

Equipment: 3'-Diam Vibra-core

GRAPHIC LOG Dip Struc. Comp. **WELL DETAIL**



DEPTH	DESCRIPTION	Notes
0'	Fibrous Peat	Riser
	Gravelly, coarse grey Sand w/ Whole mussel shells	} Screen
10'	Refusal	

APPENDIX 4

Water Quality Analyses from Margin Wells and Pump Well at end of Season (MMW-7)

ENVIRONMENTAL DIAGNOSTIC LABORATORIES

FINAL REPORT

DATE:	**09/17/1990**
CUSTOMER:	**TIMSON, SCHEPPS & PETERS, INC.**
SAMPLE DESCRIPTION:	**MONHEGAN**
PROJECT MANAGER:	**BARRY TIMSON**
DATE RECEIVED:	**08/28/1990**
LAB SAMPLE NUMBER:	**00001080**

Environmental Diagnostic Laboratories

Sample ------ 00001080-001
Information - MMW-1

Comment -----TIMSON,SCHEPPS & PETERS, INC.
MONHEGAN AQUIF

LLECTED : 08/24/1990 :　BY : BARRY TIMSON　RECEIVED : 08/28/1990 10:25

TEST DESCRIPTION	RESULT	UNIT	DETECTION	METHOD#	TESTED/ANALYST
Nitrate Nitrogen	ND	mg/L	0.20	USEPA 353.3	09/11/1990 DRB
Nitrite Nitrogen	ND	mg/L	0.005	USEPA 354.1	
	*SUBCONTRACTED				
Total Coliform	120	/100 mL	1	STDM 909A	
	*SUBCONTRACTED				

Sample ------ 00001080-002
Information - MMW-2

Comment ----TIMSON,SCHEPPS & PETERS, INC.
MONHEGAN AQUIF

LLECTED : 08/24/1990 : BY : BARRY TIMSON RECEIVED : 08/28/1990 10:25

TEST DESCRIPTION	RESULT	UNIT	DETECTION	METHOD#	TESTED/ANALYST
Fluoride	ND	mg/L	0.05	STDM 414.C	09/10/1990 DRB
Nitrate Nitrogen	ND	mg/L	0.20	USEPA 353.3	09/11/1990 DRB
Nitrite Nitrogen	ND	mg/L	0.005	USEPA 354.1	
	**SUBCONTRACTED*				
Total Coliform	0	/100 mL	1	STDM 909A	
	**SUBCONTRACTED*				
Arsenic	ND	mg/L	0.005	USEPA 206.2	08/31/1990 VTB
Barium	0.005	mg/L	0.005	USEPA 200.7	09/05/1990 DBG
Chromium	ND	mg/L	0.01	USEPA 200.7	09/05/1990 DBG
Lead	ND	mg/L	0.005	USEPA 239.2	09/10/1990 VTB
Mercury (Cold Vapor)	ND	mg/L	0.001	USEPA 245.1	08/30/1990 RGH
Selenium	0.010	mg/L	0.005	USEPA 270.2	08/31/1990 RGH
Silver	ND	mg/L	0.01	USEPA 200.7	09/05/1990 DBG
Sodium	23	mg/L	1	USEPA 200.7	09/05/1990 DBG
Cadmium	ND	mg/L	0.002	USEPA 213.2	09/10/1990 VTB

Sample ------ 00001080-003
Information - MMW-3

Comment -----TIMSON,SCHEPPS & PETERS, INC.
MONHEGAN AQUIF

LLECTED : 08/24/1990 : BY : BARRY TIMSON RECEIVED : 08/28/1990 10:25

TEST DESCRIPTION	RESULT	UNIT	DETECTION	METHOD#	TESTED/ANALYST
Nitrate Nitrogen	ND	mg/L	0.20	USEPA 353.3	09/11/1990 DRB
Nitrite Nitrogen	ND	mg/L	0.005	USEPA 354.1	
	*SUBCONTRACTED				
Total Coliform	40	/100 mL	1	STDM 909A	
	*SUBCONTRACTED				

Sample ------ 00001080-004
Information - MMW-4

Comment -----TIMSON,SCHEPPS & PETERS, INC.
MONHEGAN AQUIF

COLLECTED : 08/24/1990 : BY : BARRY TIMSON RECEIVED : 08/28/1990 10:25

TEST DESCRIPTION	RESULT	UNIT	DETECTION	METHOD#	TESTED/ANALYST
Fluoride	0.13	mg/L	0.05	STDM 414.C	09/10/1990 DRB
Nitrate Nitrogen	ND	mg/L	0.20	USEPA 353.3	09/11/1990 DRB
Nitrite Nitrogen	0.042	mg/L	0.005	USEPA 354.1	
	**SUBCONTRACTED*				
Total Coliform	2	/100 mL	1	STDM 909A	
	**SUBCONTRACTED*				
Arsenic	ND	mg/L	0.005	USEPA 206.2	08/31/1990 VTB
Barium	0.019	mg/L	0.005	USEPA 200.7	09/05/1990 DBG
Chromium	ND	mg/L	0.01	USEPA 200.7	09/05/1990 DBG
Lead	ND	mg/L	0.005	USEPA 239.2	09/10/1990 VTB
Mercury (Cold Vapor)	ND	mg/L	0.001	USEPA 245.1	08/30/1990 RGH
Selenium	ND	mg/L	0.005	USEPA 270.2	08/31/1990 RGH
Silver	ND	mg/L	0.01	USEPA 200.7	09/05/1990 DRB
Sodium	24	mg/L	1	USEPA 200.7	09/05/1990 DGB
Cadmium	ND	mg/L	0.002	USEPA 213.2	09/10/1990 VTB

Sample ------ 00001080-005
Information - MMW-5

Comment -----TIMSON,SCHEPPS & PETERS, INC.
MONHEGAN AQUIF

LLECTED : 08/24/1990 : BY : BARRY TIMSON RECEIVED : 08/28/1990 10:25

TEST DESCRIPTION	RESULT	UNIT	DETECTION	METHOD#	TESTED/ANALYST
Fluoride	0.06	mg/L	0.05	STDM 414.C	09/10/1990 DRB
Nitrate Nitrogen	ND	mg/L	0.20	USEPA 353.3	09/11/1990 DRB
Nitrite Nitrogen	ND	mg/L	0.005	USEPA 354.1	
	*SUBCONTRACTED				
Total Coliform	10	/100 mL	1	STDM 909A	
	*SUBCONTRACTED				
Arsenic	0.014	mg/L	0.005	USEPA 206.2	08/31/1990 VTB
Barium	0.018	mg/L	0.005	USEPA 200.7	09/05/1990 DGB
Chromium	ND	mg/L	0.01	USEPA 200.7	09/05/1990 DGB
Lead	ND	mg/L	0.005	USEPA 239.2	09/10/1990 VTB
Mercury (Cold Vapor)	ND	mg/L	0.001	USEPA 245.1	08/30/1990 RGH
Selenium	0.008	mg/L	0.005	USEPA 270.2	08/31/1990 RGH
Silver	ND	mg/L	0.01	USEPA 200.7	09/05/1990 DGB
Sodium	32	mg/L	1	USEPA 200.7	09/05/1990 DGB
Cadmium	ND	mg/L	0.002	USEPA 213.2	09/10/1990 VTB

Sample ----- 00001080-006
Information - MMW-6

Comment ----TIMSON,SCHEPPS & PETERS, INC.
MONHEGAN AQUIF

LLECTED : 08/24/1990 : BY : BARRY TIMSON RECEIVED : 08/28/1990 10:25

TEST DESCRIPTION	RESULT	UNIT	DETECTION	METHOD#	TESTED/ANALYST
Fluoride	ND	mg/L	0.05	STDM 414.C	09/10/1990 DRB
Nitrate Nitrogen	ND	mg/L	0.20	USEPA 353.3	09/11/1990 DRB
Nitrite Nitrogen	ND	mg/L	0.005	USEPA 354.1	
	**SUBCONTRACTED*				
Total Coliform	3	/100 mL	1	STDM 909A	
	**SUBCONTRACTED*				
Arsenic	ND	mg/L	0.005	USEPA 206.2	08/31/1990 VTB
Barium	0.015	mg/L	0.005	USEPA 200.7	09/05/1990 DBG
Chromium	ND	mg/L	0.01	USEPA 200.7	09/05/1990 DBG
Lead	ND	mg/L	0.005	USEPA 239.2	09/10/1990 VTB
Mercury (Cold Vapor)	ND	mg/L	0.001	USEPA 245.1	08/30/1990 RGH
Selenium	ND	mg/L	0.005	USEPA 270.2	08/31/1990 RGH
Silver	ND	mg/L	0.01	USEPA 200.7	09/05/1990 DBG
Sodium	36	mg/L	1	USEPA 200.7	09/05/1990 DBG
Cadmium	ND	mg/L	0.002	USEPA 213.2	09/10/1990 VTB

Sample ------ 00001080-007
Information - MMW-7

Comment ----TIMSON,SCHEPPS & PETERS, INC.
MONHEGAN AQUIF

LLECTED : 08/24/1990 : BY : BARRY TIMSON RECEIVED : 08/28/1990 10:25

TEST DESCRIPTION	RESULT	UNIT	DETECTION	METHOD#	TESTED/ANALYST
Chloride	38	mg/L	1	STDM 408.B	08/30/1990 VTB
Color	>70	SCU	1	USEPA 110.2	08/30/1990 DRB
Detergent (MBAS)	0.038	mg/L	0.025	USEPA 425.1	08/30/1990 DRB
Fluoride	ND	mg/L	0.05	STDM 414.C	09/10/1990 DRB
Hardness (Total)	191	mg/L	1	USEPA 130.2	08/30/1990 RGH
Nitrate Nitrogen	ND	mg/L	0.20	USEPA 353.3	09/11/1990 DRB
Nitrite Nitrogen	0.096	mg/L	0.005	USEPA 354.1	
	**SUBCONTRACTED*				
Odor	<1	T.O.N.	1	USEPA 140.1	09/05/1990 DRB
pH	7.9		NA	USEPA 150.1	08/30/1990 RGH
Sulfate	14	mg/L	1	USEPA 375.4	08/31/1990 RGH
Sulfide	ND	mg/L	0.1	USEPA 376.1	08/31/1990 RGH
	RECEIVED SAMPLE NOT PRESERVED FOR SULFIDE.				
Total Alkalinity	180	mg/L	1	USEPA 310.1	08/30/1990 RGH
Total Dissolved Solids	280	mg/L	10	USEPA 160.1	08/31/1990 DRB
Turbidity	1.6	N.T.U	1	USEPA 180.1	08/30/1990 DRB
Total Coliform	27	/100 mL	1	STDM 909A	
	**SUBCONTRACTED*				
Arsenic	ND	mg/L	0.005	USEPA 206.2	08/31/1990 VTB
rium	ND	mg/L	0.005	USEPA 200.7	09/05/1990 DBG
Chromium	ND	mg/L	0.01	USEPA 200.7	09/05/1990 DBG
Copper	0.05	mg/L	0.05	USEPA 200.7	09/05/1990 DBG
Iron	0.92	mg/L	0.05	USEPA 200.7	09/05/1990 DBG
Lead	ND	mg/L	0.005	USEPA 239.2	09/10/1990 VTB
Manganese	0.11	mg/L	0.01	USEPA 200.7	09/05/1990 DBG
Mercury (Cold Vapor)	ND	mg/L	0.001	USEPA 245.1	08/30/1990 RGH
Selenium	0.006	mg/L	0.005	USEPA 270.2	08/31/1990 RGH
Silver	ND	mg/L	0.01	USEPA 200.7	09/05/1990 DBG
Sodium	23	mg/L	1	USEPA 200.7	09/05/1990 DBG
Zinc	0.26	mg/L	0.01	USEPA 200.7	09/05/1990 DBG
Cadmium	ND	mg/L	0.002	USEPA 213.2	09/10/1990 VTB

Sample ------ 00001080-007
Information - MMW-7

Comment -----TIMSON,SCHEPPS & PETERS, INC.
MONHEGAN AQUIF

LLECTED : 08/24/1990 : BY : BARRY TIMSON RECEIVED : 08/28/1990 10:25

TEST DESCRIPTION RESULT UNIT DETECTION METHOD# TESTED/ANALYST

***** ANALYSTS**

HMW	HANK M. WHEAT
DBG	DAWN B. GODDARD
VTB	VENISE T. BOLDUC
DRB	DIANE R. BURNS
SEL	STEVEN E. LEAVITT
RGH	RANDY G. HAUSMAN
JTD	JONATHAN T. DYER

Hank Wheat

Laboratory Director

Reported : 09/17/1990

MONHEGAN "MEADOW" AQUIFER

PRELIMINARY HYDROGEOLOGY AND MANAGEMENT CONSIDERATIONS

Prepared For:

Monhegan Plantation
Monhegan, Maine 04852

and

James Haskell and Associates
Whittling Ridge Farm
RFD Eastbrook Road
Franklin, Maine 04634

Prepared By:

Barry S. Timson
Maine Certified Geologist #7
Timson, Schepps & Peters, Inc.
103 Water Street, P.O. Box 150
Hallowell, Maine 04347

September 1989

1.0 INTRODUCTION

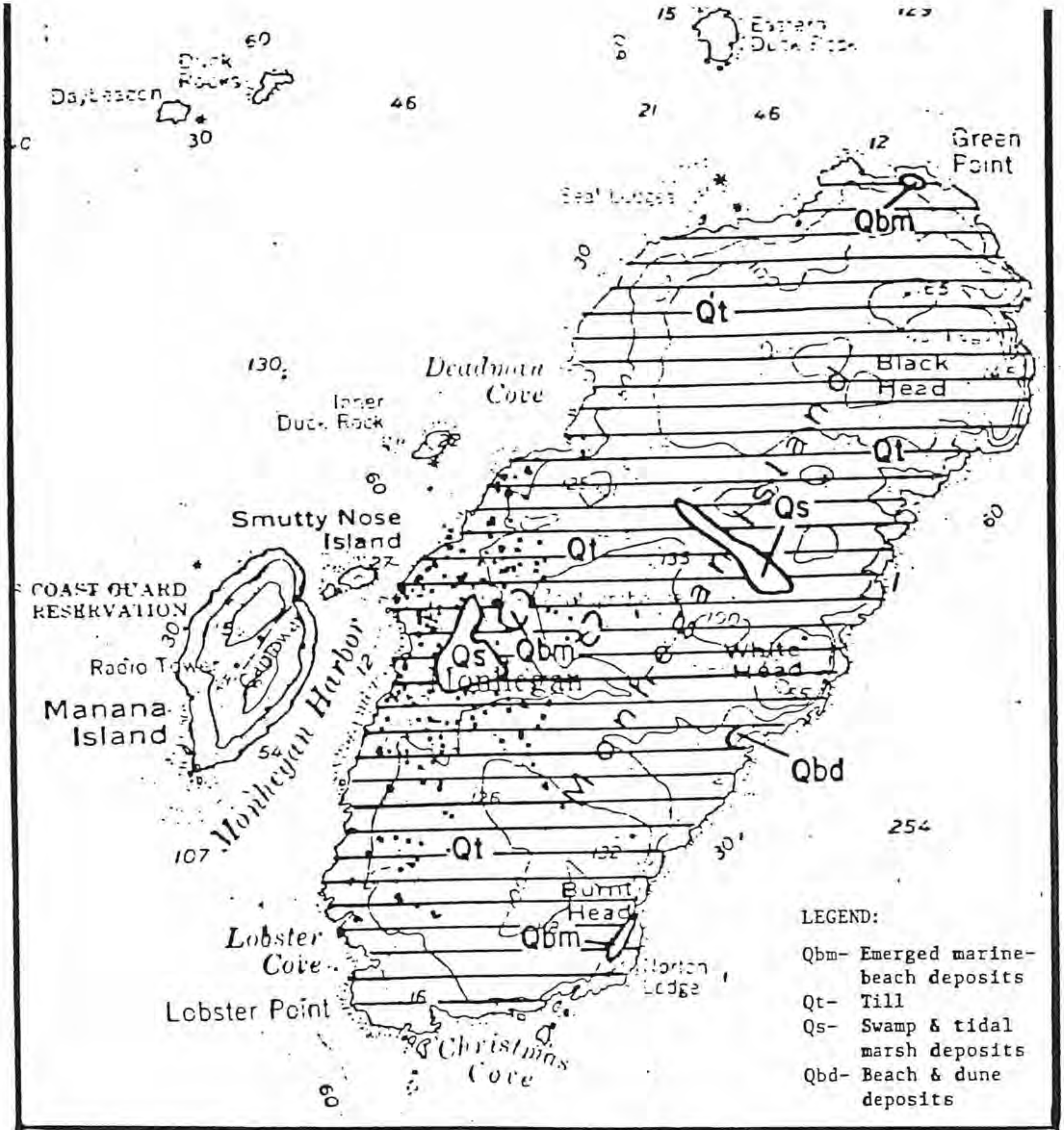
Monhegan Plantation exists as an unorganized township on the island of Monhegan. The island lies offshore and due south approximately 10 miles from Port Clyde, Knox County, on the mainland. The area of the island is approximately 0.8 square miles and is approximately 3,000 feet wide by 8,500 feet long (Figure 1). West of the island of Monhegan lies a smaller island, named Manana.

The island supports a small year-round community of approximately 85 inhabitants (Willard Boynton, personal communication), which increases dramatically during the summer months when seasonal residences, inns and guest houses are occupied. Additionally, three tourist boats transport day visitors to the island from Boothbay Harbor, New Harbor and Port Clyde each day between Memorial Day and Labor Day.

From May 1 to November 1 of each calendar year, the island community relies almost solely on a chorinated public water supply drawn from a sand and gravel aquifer located beneath "The Meadow", a bog wetland which lies within the heart of the developed village area on the western side of the island (Figure 1). During the remaining months of the year, year-round residents utilize several drilled bedrock wells, dug wells, and cisterns for water supplies. Salt water and surface stream water is utilized by several commercial businesses to limit their dependence on fresh-water supplies delivered by the public water supply. It is estimated that 80% of the potable water consumed on the island on a year-round basis is derived from the Meadow Aquifer and that this aquifer serves as a ~~soul~~ sole-source aquifer for the community (Maine State Planning Office, 1988).

The public water supply, managed by the Monhegan Water Company, is pumped from the aquifer through a combination of ten, 2" diameter well points driven through peat and clay into the upper levels of the aquifer. The well points are anywhere from 30' to 50' beneath the surface of the meadow. The distribution system consists of a pumping station, two 17,500 gallon stand pipes, and approximately 20,000 feet of surface water pipe.

The objective of this report is to provide an initial hydrogeologic characterization of the Meadow Aquifer based on previous field investigations and to present management considerations for its future use with regard to capacity and protection of water quality.



SURFICIAL GEOLOGY MAP

Figure:2

Scale:

0 1000 2000 FEET

Source . **Surficial Geology Map Monhegan Quadrangle**

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2.0 HYDROGEOLOGIC SETTING OF MONHEGAN ISLAND AND THE MEADOW AQUIFER

2.1 Geologic Setting

Monhegan is a submerged monadnock of resistant bedrock. The bedrock consists of Devonian age gabbro and diorite mafic intrusive rocks containing a system of joints and fractures with veins of both basalt and coarse-grained granite composition (Hussey et al., 1985; Lord, 1900).

The island is cut by two prominent sets of fractures. One set trends N 55° E and the other set trends N 55-60° W.

The surficial geology of the island is limited mostly to thin, bouldery ablation till deposits overlying the bedrock surface on topographic highs, slopes and intervening valleys. Bedrock outcrops occur regularly projecting through the thin till (Thompson and Timson, 1977)(Figure 2).

Two east-west trending lows through the island are underlain by glacial-marine deposits. The northerly valley is underlain by the glacio-marine silt and clay deposits of the Presumpscot Formation. The more southern valley contains both glacio-marine silts and clays, but also includes thicker (greater than 5') linear deposits of marine sand.

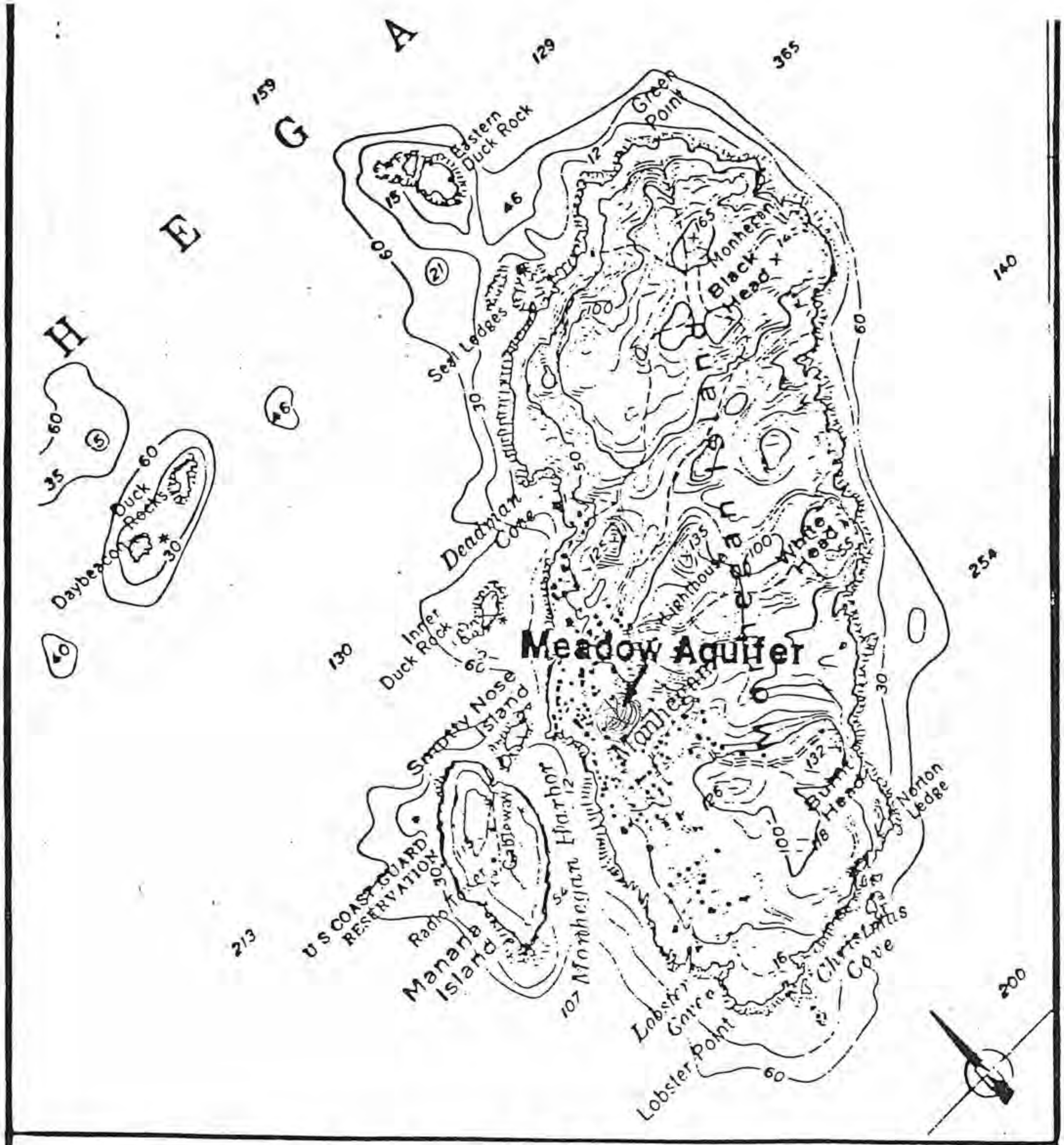
Wetlands occur at both the eastern and western ends of these 2 valleys with through-flowing intermittent streams draining the higher portions of the lows. The eastern end of the more southern valley is the location of "The Meadow" wetland. Streams are absent over the rest of the island.

2.2 Climate

The average annual temperature of mid-coast Maine, and therefore, Monhegan Island is 46° F (Lautzenheiser, 1959). The average annual precipitation exceeds 49", with 44% of the precipitation occurring between April and September and 17% occurring between June 1 and August 31 (USDA, 1987).

2.3 Geology of "The Meadow Aquifer"

The Meadow is a 9 acre bog wetland with 3 intermittent streams



MONHEGAN ISLAND

Figure:1

Scale:

0 1000 2000 Feet

Source. **USGS 7.5 Monhegan Quad.**

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entering it from the north, east and south (Figure 3). It is drained by an intermittent stream which runs beneath the main gravel road of the village west and flows into Monhegan Harbor across a small beach known locally as Swim Beach. The Meadow is often flooded during the winter and spring months as well as during periods of prolonged precipitation.

The drainage basin for the meadow encompasses the 3 intermittent stream basins as well as the immediately adjacent slopes which deliver surface sheet runoff and shallow ground water runoff to the meadow wetland. The drainage basin is approximately 69 acres in area and includes about one-third of the developed village area (Figure 4).

In 1976 and 1977, unpublished investigations of the geology and stratigraphy of the surficial deposits underlying the meadow was undertaken by this author. Forty-one small-diameter cores (Davis Peat Corer) and wash-borings were taken and penetrated the sediments underlying the meadow.

The horizontal location of the coring and boring stations was determined utilizing measuring tape and compass readings, as well as utilizing sextant readings from prominent local features surrounding the meadow and plotted on an enlarged aerial photograph. Vertical control was not established.

The results of the subsurface stratigraphy investigations indicates that the Meadow is an emerged marine basin infilled with both coarse- and fine-grained post-glacial sediments, lacustrine clays, and organic peat deposits.

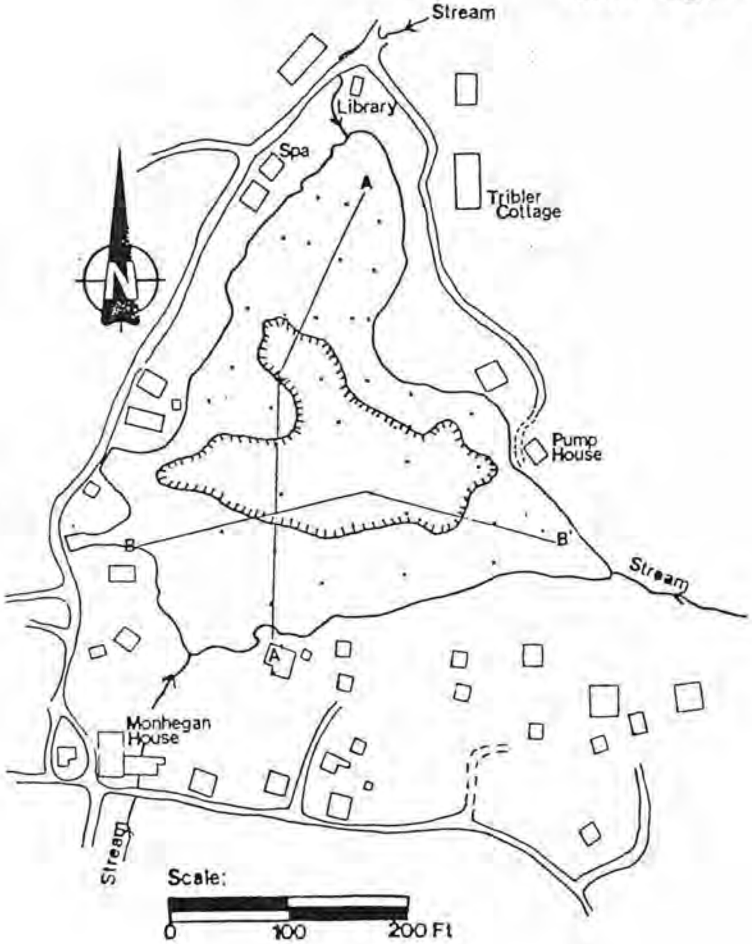
The organic peat deposits reach a maximum thickness of approximately 18' in the south-central portion of the basin. The peat deposit thins everwhere within the basin towards the edges of the meadow basin (Figure 3).

The surface organic peat layer is underlain throughout most of the basin by a grey-brown layer of lacustrine (lake) clay which reaches a maximum thickness of approximately 25' in the south-central area of the meadow. This lake clay thins and interbeds with sand or sand and gravel lenses toward the stream inlet corners of the meadow basin. These sand or gravel lenses, ranging in maximum thickness from 5' tc 15', are interpreted to be stream and related stream delta sediments deposited where the streams entered the meadow when it existed as an open pond or lake.

The organic peat and lacustrine clays are underlain, in the mid-portions of the meadow basin by a coarse marine sand with a significant fraction of marine mollusc shell fragments. This marine sand, with gravelly layers, infills two separate basins beneath the aquifer. The sand reaches a thickness of about 12' beneath the northern section of the meadow, thins to approximately 5' along an east-west trending subsurface bedrock high, and thickens dramatically to greater than 80' in a deep central basin

Figure 3

Geologic Cross Sections: The Meadow
Monhegan Island, Maine



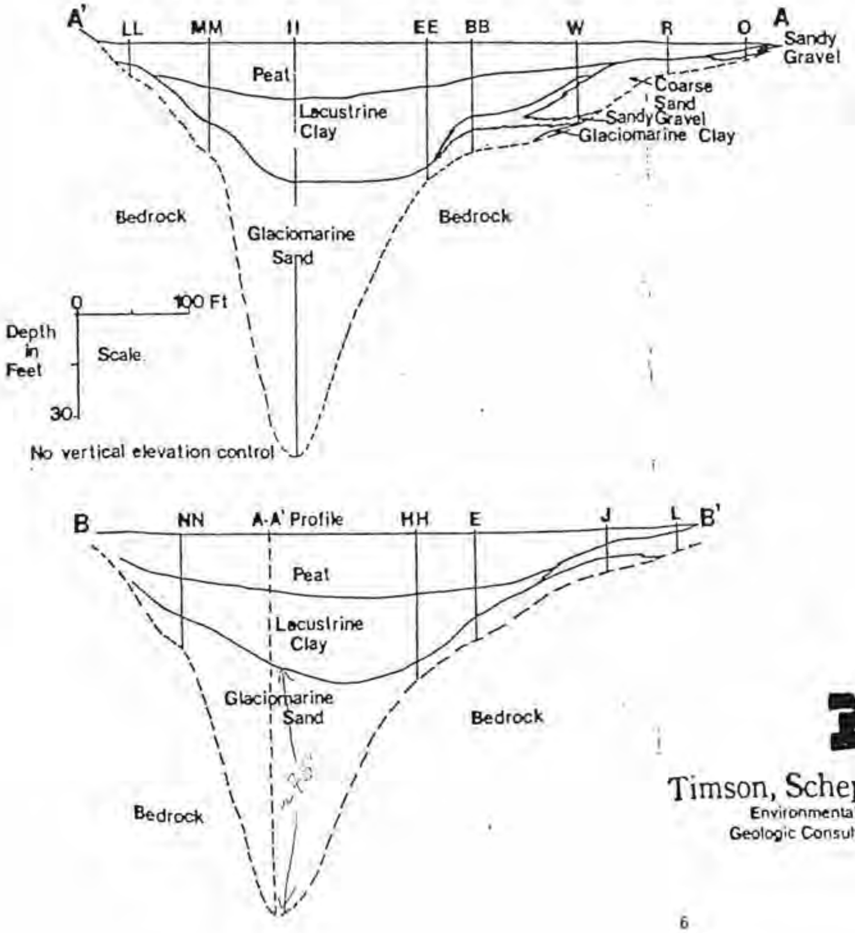


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Figure 4: Drainage basin of the meadow on Monhegan Island. Watersheds labeled A, B, and C are surface stream basins, while areas labeled D1, D2, D3, and D4 direct overland flow to the meadow.

DRAINAGE OF "THE MEADOW"

Figure:4

Scale:

0 500 1000 FEET

Source: USGS 7.5 Monhegan Quad.

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which thins both south and east to a thickness of 10' to 5' before pinching out at the margins of the basin (Figure 5).

This marine sand serves as the source of ground water for the Monhegan Water Company (MWC) supply. The MWC well field penetrates the eastern portion of the deep marine sand aquifer where the aquifer is less than 10' in thickness.

Several cores taken in the northern portion of the basin penetrated a thin layer of a blue-gray clay silt commonly recognized as a glacio-marine deposit and identified elsewhere as the Presumpscot Formation (Bloom, 1960; Thompson, 1978) beneath thin layers of the marine sand. The blue-gray silt of the Presumpscot may underlie the marine sand elsewhere in the basin where the sand is much thicker, but the wash boring technique utilized for determining the thickness of the coarser deposits presented limitations in identifying thin layers of fine-grained sediments at depths greater than 5' to 10'. The Davis Peat Corer is limited to a penetration of only about 0.6' maximum in coarser-grained sediments -- wash borings were required for any coarse deposit of any substantial thickness.

The marine sand most likely is underlain by bedrock ~~of~~ or thin, bouldery till deposits. The bottom of the aquifer unit was determined to be the point at which the small-diameter wash boring refused further penetration. Refusal could easily have occurred at a cobble, boulder, or ledge surface without definitive identification of the geologic character of the refusal surface.

Subsurface investigations were limited along the western margin of the basin. Here, the meadow has been filled in places for house lots and for the main gravel road of the village.

2.4 Hydrogeology of "The Meadow Aquifer"

There is little known published material on the hydrogeology of the aquifer. The Monhegan Water Company has not conducted pump tests or retrieved sediment samples of the aquifer to characterize the hydaulics of ground water flow and storage within the aquifer.

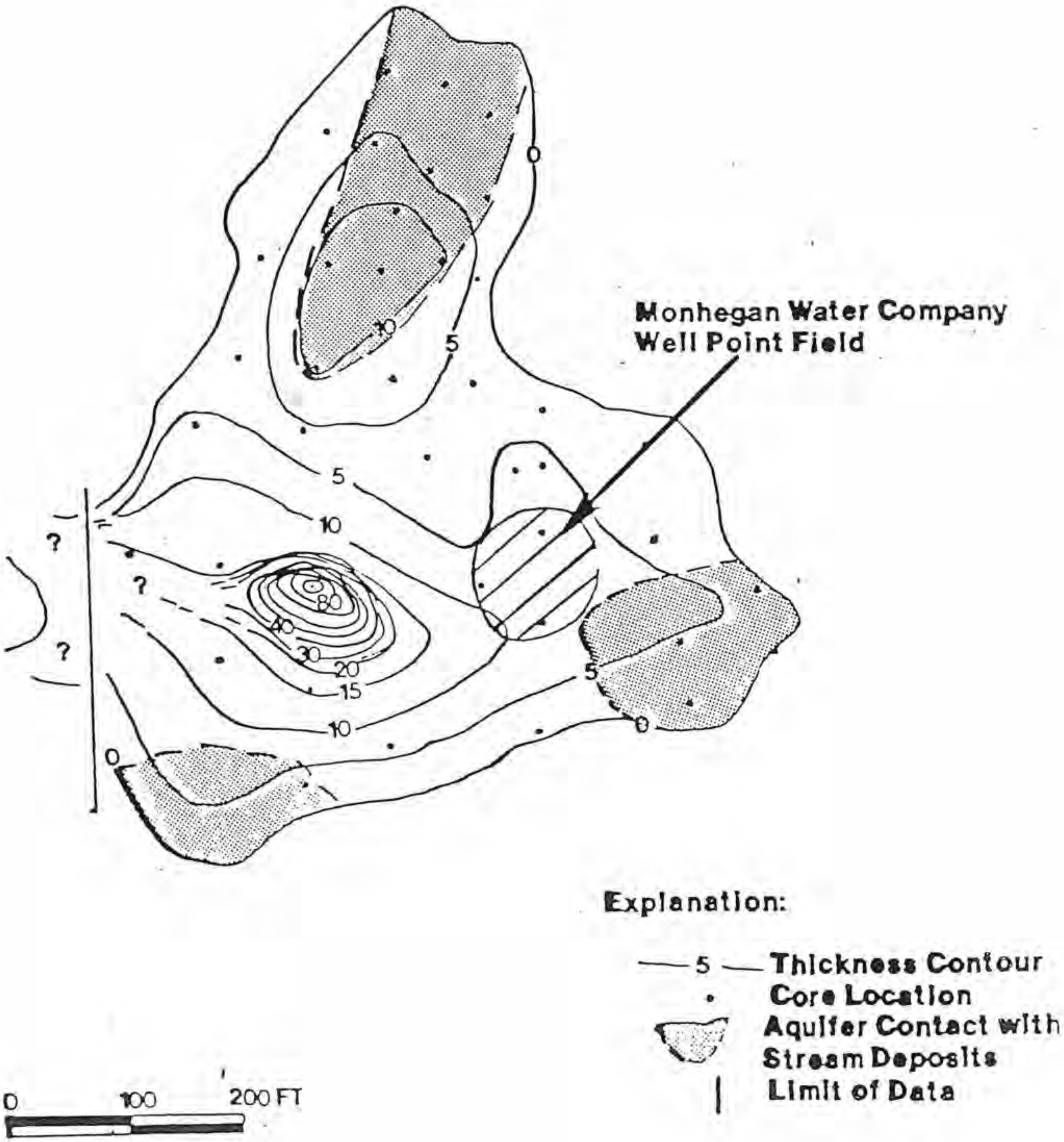
The geologic investigations presented in section 2.3 however, allow some preliminary considerations of the hydrogeology of the aquifer. An isopach (thickness) map (Figure 5) was prepared from the three-dimensional stratigraphic data of the geologic study. This allows for a determination of the volume of the aquifer as well as an estimate of the porosity or capacity of the aquifer.

2.41 Volume of the Aquifer

The volume of the aquifer, as determined from digital planimeter volume measurement estimates from the isopach map, is approximately 1,100,000 cubic feet. This volume estimate is a minimum estimate as it does not include an accurate determination

FIGURE 5

Thickness of the Monhegan "Meadow" Sand and Gravel Aquifer



include volume of the stream delta and channel deposits which lie above and are hydraulically connected to the marine sand aquifer.

2.42 Storage Capacity of the Aquifer

The porosity of the marine sand (measurement of the void space between solid particles which can be occupied by ground water) is estimated to be between 15 and 20% (Driscoll, 1986). This estimate indicates that the minimum ground water storage capacity of the aquifer is from 1,242,000 to 1,656,000 gallons. ⇒ but this cannot all be used at once ⇒ sw intrusion

2.43 Aquifer Recharge

The hydrologic cycle in Maine is described by Caswell (1978). Precipitation either is returned to the atmosphere through evaporation and plant transpiration, or is divided between stream runoff and infiltration into soils and bedrock. Some ground water only travels a small distance before it is discharged back to the surface to become surface runoff.

In Maine, approximately 40% of the average annual precipitation is lost to evaporation and plant transpiration (Gerber and Rand, 1982). The percentage of precipitation which infiltrates into the soil and bedrock to become ground water varies with soil type, slope and land surface condition. In general, the type and thickness of soil cover dictates the recharge rate to the ground water table in bedrock below.

The 3 streams which enter the Meadow are all intermittent and contain very little base flow. In other words, they serve to discharge surface runoff and contain little, if any, ground water flow which has returned to the terrain surface. As mentioned earlier, the runoff from these streams mostly ponds in the meadow and then discharges to the ocean through a culvert and stream draining across Swim Beach.

Recharge to the aquifer occurs from several sources:

- o Direct infiltration of precipitation and snow and ice melt through the peat and/or lake clay to the aquifer below.
- o Direct infiltration of runoff and precipitation through the stream deposits entering and in contact with the aquifer at the northern, eastern and southern ends of the meadow.
- o Shallow bedrock ground water flow from the adjacent ground water "shed".

Infiltration through the peat and lake clay is minimal. Both the fibrous peat roots and plant matter retain moisture readily and the lake clay is an effective barrier to the passage of ground water. Gerber and Rand (1982) estimate that only 5% of the average annual precipitation infiltrates through fine-grained, clay-silt deposits, which represents an average recharge rate of about 0.11 gallons per minute (gpm) per acre.

The sand and gravel deposits which include the stream channel and delta deposits at the entrance of each of the streams entering the meadow are capable of transmitting greater amounts of precipitation because of their increased porosity and permeability characteristics. Gerber (1986) estimates that these deposits can transmit up to 50% of the average annual precipitation rate, or about 1.30 gpm per acre.

The remainder of the "Meadow" drainage basin is best characterized as exposed bedrock or covered with thin ablation till deposits (Thompson and Timson, 1977) with the exception of a small deposit of fine-grained sand which occurs along the stream entering the eastern side of the meadow. Gerber and Rand (1982) estimate that exposed bedrock or bedrock covered with thin, sandy till deposits transmit approximately 25% of the average annual precipitation, or 0.65 gpm per acre. Fine-grained sand deposits can transmit 0.70 gpm per acre of terrain.

On the basis of these estimates, the average summer month (June through August) recharge available to the meadow aquifer was calculated by totalling the average recharge rate for each of the deposits in the drainage basin of the aquifer (Table 1). The average summer month precipitation rate is approximately .17 times the average annual precipitation rate of 49.7 inches.

TABLE 1

GROUND WATER RECHARGE SOURCES AND SUMMER MONTH RATES FOR THE DRAINAGE BASIN ELEMENTS OF THE MEADOW

	Area	Infiltration Rate (GPM)	Recharge to Aquifer (Gallons)
Meadow Clay:	6.7A	0.11	66,120
Stream Deposits:	2.2A	1.30	255,546
Thin Till & Bedrock:	59.7A	0.65	3,467,304
Fine Sand:	0.8A	0.70	50,037

TOTAL SUMMER MONTH RECHARGE RATE: 3,839,007

A total of 3,839,000 gallons recharge the meadow aquifer during the three summer months — those months where water withdrawals from the aquifer are heaviest. The drought recharge rate is considered to be approximately 60% (Gerber and Rand, 1982) of this rate, or approximately 2,303,400 gallons.

These recharge rates are considered to be the "safe" recharge rates for the average summer month precipitation rate and the drought summer month precipitation rate. Extraction of ground water volumes greater than these recharge volumes will significantly lower the ground water table within the aquifer and, perhaps, increase the possibility of salt-water intrusion to the aquifer.

3.0 USE OF WATER FROM THE MEADOW AQUIFER

3.1 Summer Water Use

Flow meters were installed within the pipe system of the Monhegan Water Company in 1988. Since that time, accurate monthly records have been kept of the volume of water pumped from the meadow aquifer. In 1988, from June 1 to September 3, approximately 3,125,000 gallons of water were extracted from the aquifer (Willard Boynton, personal communication). In 1989, between May 14 and September 5, approximately 2,500,000 gallons of water were pumped from the aquifer (Willard Boynton, personal communication).

The summer of 1988 was considered by many on Monhegan as the summer of highest tourist visitations to Monhegan. By contrast, tourist visitations to the island was down, and considered to be more normal.

There are 141 individual dwelling units on Monhegan. Commercial rental units available for nightly or weekly rental number 132 (Island Inn, Monhegan House, Trailing Yew, Tribler Cottage, Shining Sails, Hitchcock House). This study assumes that the maximum capacity of the dwelling units is 4 individuals per unit; and that the maximum capacity of each rental unit is 2. Day visitors to the island are brought by several tourist boats (The Balmy Days from Boothbay Harbor, The Hardy III from New Harbor, and The Laura B from Port Clyde). Their combined maximum passenger capacities are 360 (several trips by The Laura B).

If the volume of water pumped from the aquifer during the summer months in 1988 is assumed to have been consumed by the island inhabitant capacity, excluding use by day visitors, then the average daily water use per individual is calculated to be 39.7 gallons.

A 40 gallon per person per day consumption rate for Monhegan Island is a reasonable estimate. The U.S. EPA Design Manual (1980) estimates that the average water use of the U.S. citizen is approximately 55 gallons per day. Water use on Monhegan is less due to the islander's experience with limited winter water supplies from dug wells, cisterns, and low yield bedrock wells. Summer resident use is also less due to limited access to laundry facilities, common bathroom facilities in the inns and commercial rental units, and previous experiences with island-wide summer water shortages.

D ~~S~~ay visitors are estimated to use less than 1 gallon per day per person due to the paucity public toilets, public water sources, and the limited visitation hours to the island (5 to 7 hours).

If Monhegan Island is at capacity for the present number of dwelling and commercial units, as well as the number of day visitors to the island, water demand during the three summer months will be approximately 3,080,000 gallons. This consumption rate is higher than the expected drought condition recharge rate to the aquifer over the same time period, but less than the average rate of recharge expected.

This capacity relationship appears to be supported by historical flow volumes recorded for the summers of 1988 and 1989. The year of 1988 was a year of known drought conditions during the summer months. It was also a year of higher than usual visitations to the island, by both overnight and daily visitors. No actual figures for visitations exist. The volume of water withdrawn from the aquifer exceeded the drought year safe annual recharge rate and water shortages were a common occurrence in the month of August. While no water quality problems were recorded, the water table within the aquifer was lowered substantially such that the Monhegan Water Company wells were often pumping substantial volumes of air along with the water (Willard Boynton, personal communication).

During the summer of 1989, demand for water from the aquifer was substantially lower than that in 1988. No water shortages were reported. This was a year of average summer precipitation and lower than capacity visitations to the island by tourists (William Payne, personal communication). Only 2,500,000 gallons of water were removed from the aquifer from May 14 to September 5, approximately 625,000 gallons less than in the previous year over a longer time frame. This useage level was approximately 1,300,000 gallons less than the expected recharge rate.

3.2 Off-season Water Use

The Monhegan Water Company operates the surface water supply system from May 1 to November 1 of each year. From May 1 to June 1, and from Labor Day to November 1, water useage is most likely far less than during the summer months.

Presumabely, the meadow aquifer is fully recharged by May 1 of each year, since the predicted capacity is less than half of even the summer three-month drought recharge rate. The predicted average annual recharge rate is approximately 13 times that of the predicted maximum capacity of the aquifer. Presumabely the ground water in the aquifer is replaced between 13 and 20 times during the average precipitation year.

Based upon the assumption of a use rate of about 40 gallons per person per day, it is doubtful if a volume of greater than 200,000 gallons is pumped from the aquifer during the month of May (consumption by 85 inhabitants, refilling of tanks and pipes).

Consumption also decreases dramatically after Labor Day of each year, but not to the levels of May useage. In September, most of the commercial room establishments are still open and utilized. Many of the seasonal dwellings, however, are closed for the season by the end of the first or second week in September. It is estimated that no more than 650,000 gallons of water are removed from the aquifer during the month of September. This amount is about one-half the capacity of the aquifer. Most likely, the aquifer is completely recharged from fall seasonal precipitation very shortly after the surface water system is shut down on November 1.

3.3 Water Use Vs. Aquifer Recharge Rate: Consequences to the Existing System

As previously stated the volumes of ground water extracted by the existing surface water system may exceed the "safe" summer month recharge rate to the aquifer only during times of drought condition and maximum utilization of island residential and tourist facilities.

Recharge rates during normal precipitation years and "normal" seasonal island population levels are not exceeded, and the aquifer should recharge completely by late Fall of each year. During an average precipitation year, the capacity and recharge rate to the meadow aquifer during the summer months appears to exceed maximum expected use demand by approximately 759,000 gallons, or the amount of water expected to be used by an additional 200 summer inhabitants.

The consequence of exceeding the "safe" recharge rate may result in the lowering of the ground water table within the aquifer such that the existing Monhegan Water Company well point depths and pump pressures are incapable of sufficient yields to replace water within the tank and pipe storage elements. Another possible consequence of withdrawing volumes which exceed the "safe" aquifer recharge rate is the potential of ultimately drawing brackish or saltwater toward the well points either from the western margin of the aquifer or from the base of the aquifer (Figure 6). While the later consequence cannot be ruled out as a possible or potential problem, the former consequence appears to be more the present problem.

During periods of drought and excessive demand on the water system, the Monhegan Water Company pumps draw ever increasing amounts of air per equivalent pump time intervals. Clearly, this condition suggests that the aquifer water table has lowered substantially with respect to the depth levels of the well points. The limitation of the system appears to be that the well points are not placed deep enough within the aquifer to offset the temporary lowering of the aquifer ground water table during drought and excessive use summer seasons.

The aquifer thickness map indicates that the Monhegan Water Company well point field could be placed further west deeper into the aquifer. A possible consequence of doing this, however, could be to induce salt water intrusion into the aquifer or the well points. Information presently available is not adequate to determine if moving and deepening the well points will result in salt water intrusion problems.

Salt water intrusion is a possible problem when extracting ground water supplies from islands. Salt water corrodes metal plumbing fixtures, is unhealthy to drink, and is expensive to desalinate to render it potable. Fresh water as ground water will occur within the fractured bedrock of an island as a "lens" of fresh water floating on salt water. This is the case since salt water is denser than fresh water (density of salt water 1.025 grams per cubic centimeter). A thick zone of brackish ground water occurs near the salt water interface shown on Figure 6, due to mixing caused by tidal fluctuations and by ground water moving along the salt water interface. The theoretical salt water interface is located about 40 times the depth below Mean Sea Level as the surface of the ground water is elevated above Mean Sea Level (Ghyben-Herzberg Principle, Driscoll, 1986).

Figure 6 is a theoretical section of the fresh water lens beneath Monhegan and Manana. Monhegan Harbor allows a channel of salt water to occur as ground water beneath the harbor. However, the pressure heads of the ground water flowing from both Manana and Monhegan probably limit the salt or brackish water to a very limited depth beneath the surface.

Placing the well points both closer to the harbor and deeper, place them closer to salt water as well as allowing for further incursion of a salt or brackish water cone when the well points are pumped (Figure 7). Since the subterranean boundary of the theoretical lens is 40 times the height of the ground water table above Mean Sea Level, lowering the ground water table within the aquifer by 5' will theoretically result in a 200' intrusion of a salt water cone toward the bottom of the well. While this theoretical situation may be deviated from substantially because of the fracture patterns in the bedrock, possible confined nature of the aquifer, and other factors which may preclude salt water intrusion into the meadow aquifer, caution must be the rule of thumb and further hydrogeologic investigations of the character of the aquifer should occur to evaluate the potential for salt water intrustion before the well point field is moved.

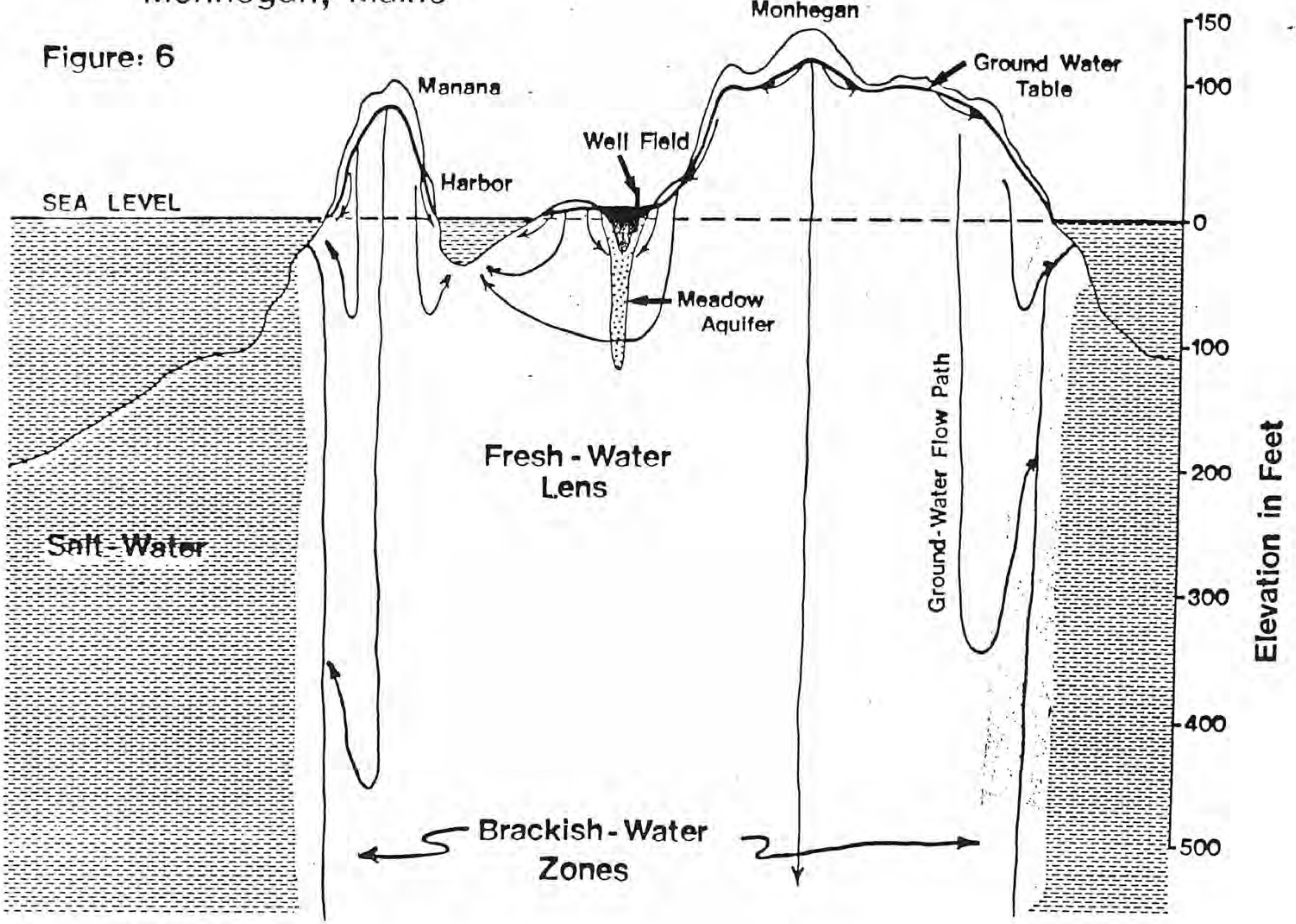
Figure 6: Hypothetical section through Monhegan Manana illustrating the relationship of the fresh ground water lens to surrounding marine and salt ground water. The boundary between the fresh ground water lens and the salt ground water is a zone of brackish water where fresh and salt water mix. The "Meadow" aquifer receives shallow ground water from adjacent fractured bedrock.

Figure 7: Hypothetical relationship between fresh and salt water at the coastline. Note that withdrawing water from a well near the shoreline acts to displace the fresh/salt water interface toward the well by an amount greater than the cone of depression caused by pumping the well.

From Caswell (1979).

Hypothetical Fresh-Water Lens
Monhegan, Maine

Figure: 6



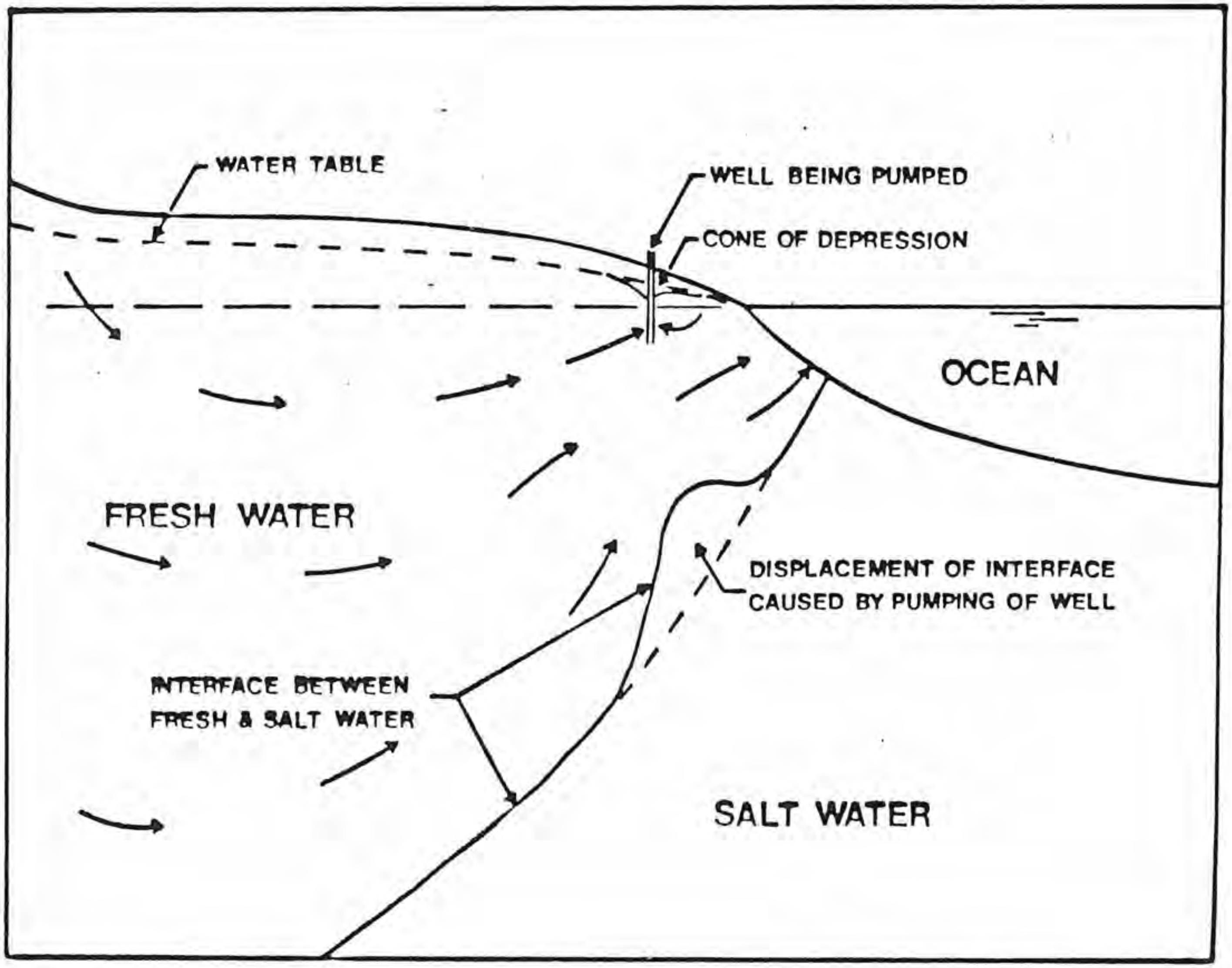

WATER TABLE
WELL BEING PUMPED
CONE OF DEPRESSION
OCEAN
FRESH WATER
DISPLACEMENT OF INTERFACE CAUSED BY PUMPING OF WELL
INTERFACE BETWEEN FRESH & SALT WATER
SALT WATER

Figure: 7

4.0 WATER QUALITY & MANAGEMENT CONSIDERATIONS

The Meadow Aquifer lies within the boundaries of a 70-acre watershed (Figure 4). This basin can be divided into several sub-basins. First, 3 sub-basins are the watersheds of intermittant streams which flow directly into the meadow. Four additional sub-basins surround the meadow. Within these sub-basins, overland runoff flows into the meadow, as does shallow ground water which originated from infiltration of precipitation on these sub-basins. These sub-basins are individually delineated as A,B,C for the stream watersheds and D1 through D4 for the adjacent, surrounding sub-basins (Figure 4). The quality of the surface and shallow ground water flowing into the meadow from these sub-basins could influence the quality of the water within the aquifer.

Water quality utilized from the aquifer over the last 20 years has consistently met EPA and State primary drinking water standards. Occasional low levels of bacteria have occurred, but more prevalent has been the aesthetic contamination from elevated levels of iron and manganese (Maine State Planning Office, 1988). It is not known if the elevated levels of iron and manganese are natural background minerals within the aquifer or minerals added to the water supply from the old piping system. Water samples submitted to the Department of Human Services for quality testing are taken from a faucet, not directly from the aquifer.

Water samples taken in April of 1988 from the public water system indicated both sodium and chloride levels to be well within drinking water standards.

Historically, approximately 26 water quality measurements of both dug and drilled wells have been issued by the Maine State Public Health Lab. The most prevalent water quality problem with dug well water supplies is excessive bacteria. Of 6 drilled well water samples, 1 yielded high sodium levels while one indicated hydrocarbon contamination. No samples have shown excessive nitrate levels.

Given that dug well water on the island consistently has tested unsatisfactory for bacteria, this type of water quality problem appears to the major pollution problem with respect to shallow ground water. Deeper ground water, tested from drilled wells, has not shown bacteria as being a water quality problem.

The meadow aquifer is partially isolated from surface and shallow, ground water runoff by a layer of peat and lake clay. Peats and decomposed wetland plant matter is known to be an effective filtering media for the removal of bacteria from septic system leachate. The peat acts as a filter, adsorptive media, and harbors its own microbial organisms which act to retain, detain, and destroy coliform bacteria. It is this natural peat filter and the impermeable lake clay which may be preventing bacterial pollution of the aquifer ground water or, at least, substantially reducing the levels of harmful bacteria which enter the aquifer.

As mentioned earlier, the 3 intermittant stream basins may serve to deliver bacteria to the ground water aquifer, as the mouths of the streams are hydraulically connected to the margins of the aquifer marine sand.

If this bacteria transport pathway is a present phenomenon, increased introduction of bacteria due to the establishment of new septic systems or the conversion of overboard discharge systems to in-ground septic systems could increase the level of bacterial pollution within the aquifer, especially during the summer season.

An additional threat to the future water quality of the aquifer could be the introduction of nitrate-nitrogen from existing, new, or overboard conversions from shallow ground water leachate plumes from adjacent slopes. These nitrate-nitrogen bearing leachate plumes could enter the subsurface aquifer from plumes which enter the bedrock fracture system directly beneath the septic system and travel to the aquifer marine sand directly without passing through the overlying peat deposits or being detained by the lake clay underlying the surface wetland and peat deposits.

Additional hydrogeologic information on the bedrock fracture system, the hydraulic connectivity between the streams and the aquifer marine sand, and the hydraulics of the aquifer and well field should be evaluated to determine the potential threat of these water quality problems as well as to determine the future threat due to salt water intrusion.

Stream drainage basin B presently is zoned Resource Protection for the purposes of protecting water quality of runoff entering the meadow. The remaining stream basins and other adjacent meadow runoff watershed basins primarly occur within a development zone - most areas having been historically within the village area prior to the adoption of zoning standards.

These zones should be reviewed as to allowed practi~~s~~ces, subsurface sewerage disposal additions, conversions, and storage of large volumes of toxic hazardous wastes with respect to their potential impact on the water quality of the meadow aquifer.

5.0 CONCLUSIONS

Monhegan Plantation utilizes ground water drawn from a marine sand aquifer located beneath "The Meadow" for approximately 80% of its potable water supply. The capacity of this aquifer is estimated to be approximately between 1,242,000 and 1,656,000 gallons. The average annual recharge rate to the aquifer is between 13 and 18 times the capacity of the aquifer, indicating that greater volumes of water are available for use.

Estimates of the population capacity of the island and summer month recharge to the aquifer indicate that water demand from the maximum available summer population capacity exceeds the "safe" recharge rate to the aquifer during drought conditions, but not during average summer precipitation recharge conditions. Under average recharge conditions, the "safe" recharge rate can theoretically support water use from an additional 200 individuals consuming 40 gallons per day over the 3-month summer period.

Estimates of aquifer recharge rate and water demand appear to be confirmed by data supplied for water use during the 1988 summer season, a known drought season coincident with heavy island visitations. Water shortages were common during the latter part of the 1988 summer season.

The consequences of pumping water volumes from the aquifer which exceed the "safe" seasonal recharge rate are a lowering of the aquifer water table or possible inducement of salt-water intrusion into the aquifer. It is apparent that the former condition occurred during the 1988 season such that the water table in the aquifer lowered to such an extent that the Monhegan Water Company well points were at or near the lowered water table level.

This problem might be alleviated by locating the well points further west in the meadow to penetrate deeper levels within the aquifer. A possible consequence of undertaking this relocation and deepening of well points may be an increased inducement of salt-water intrusion into the aquifer and water supply system.

The aquifer is recharged directly from 3 intermittent stream basins entering the meadow as well as from shallow ground water flow from surrounding higher terrain. There is a direct hydraulic connection between stream deposits and the mouths of the entering streams, whereas overland runoff and very shallow ground water discharge to the aquifer may be isolated from the aquifer by peat and lake clay deposits.

Historical records of water quality testing of the Monhegan Water Company by the State of Maine indicate that the surface water supply has consistently met Maine Primary Drinking Water standards, with the exception of elevated levels of iron and manganese. Excess levels of these constituents are not harmful from a human consumption viewpoint, but impart an undesirable aesthetic quality to the water color and taste. Excessive amounts of iron and manganese may be a consequence of the corrosion within the surface pipe system rather than an inherent aquifer ground water quality problem.

Salt-water intrusion has not been a documented water quality problem in the aquifer. Levels of sodium and choride are within drinking water standards. Future demand increases on the water system, however, may necessitate movement of the well points closer to the boundary of the island fresh-water/salt-water lens.

Residential development surrounding the aquifer cannot be documented as adversely effecting aquifer ground water quality at this point in time. Inadequate subsurface sewerage treatment within the watershed boundaries of the meadow could lead to increased bacteria and nitrate-nitrogen levels within the aquifer. Excessive bacteria is removed from the present system by chlorination, and nitrate-nitrogen levels in the aquifer are well within drinking water standards.

Bacteria and viruses, as well as nitrate-nitrogen, from surface overland runoff and shallow ground water runoff into the meadow may be effectively removed from water by filtration through the peat and clay deposits overlying the aquifer marine sand. They may also be diluted to lower, less toxic levels, due to the high flushing rate within the aquifer, itself.

Future prudent management of the aquifer ground water supply quantity and quality will require further hydrogeologic investigations of the aquifer to determine the likely potential for salt-water intrusion. Surrounding watershed zoning district standards should also be reviewed with respect to future increases in subsurface sewerage disposal, conversions from overboard discharge to subsurface sewerage disposal, and storage of hazardous materials, particularly within those zoning districts encompassing the stream watersheds which discharge directly into the meadow.

RECOMMENDATIONS:

1. Further define the hydraulics and hydrogeologic characteristics of the marine sand aquifer by conducting pump tests from the existing well point system.

2. Further define the three-dimensional geology of the western margin of the aquifer to determine its connectivity or isolation from marine waters near Swim Beach by conducting subsurface coring and boring investigations.

3. Conduct a coordinated aquifer and input stream water quality testing program to determine the extent to which surface

water and shallow ground water runoff influence aquifer ground water quality.

4. Review existing zoning standards for those developed areas surrounding the meadow with regard to increase in subsurface sewerage systems, enlargement of these systems, conversions from overboard discharge to subsurface systems and the storage of hazardous waste.

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APPENDIX C

Maine DWP Transient Public Water System Application for a New System or a New Well

DEPARTMENT OF HEALTH AND HUMAN SERVICES

TRANSIENT PUBLIC WATER SYSTEM

APPLICATION FOR A NEW SYSTEM OR NEW WELL

* Approval of a new public water system requires well and system approval. Compliance of the entire water system will be evaluated during a comprehensive inspection by the Drinking Water Program.

Restaurant

Boys and Girls Camp

Campground

Hotel

Motel

Hunting Lodge

Golf Course Clubhouse

and others

Drinking Water Program
Division of Environmental Health
Maine Center for Disease Control and Prevention
Department of Health and Human Services
11 State House Station, 286 Water Street
Augusta, Maine 04333-0011
TEL: (207) 287-2070 TTY Users: Dial 711 (Maine Relay)
FAX: (207) 287-4172
Web Address: http://www.medwp.com

PWS Inspector: ____

PWS Inspector Address: ____

Phone:____________________________Fax: ____________________________

Date this packet was sent or delivered in person: ____________________________

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IS YOUR ESTABLISHMENT A PUBLIC WATER SYSTEM?

A public water system is defined as any publicly or privately-owned system of pipes or other constructed conveyances, structures and facilities through which water is obtained for or sold, furnished or distributed to the public for human consumption, if such system has at least 15 service connections or serves at least 25 individuals daily at least 60 days out of the year or bottles water for sale. The term "public water system" shall include any collection, treatment, storage or distribution pipes or other contstructed conveyances, structures or facilities under the control of the supplier of water and used primarily in connection with such a system, and any collection or pretreatment storage facilities not under that control that are used primarily in connection with such a system.
(From the State of Maine Rules Relating to Drinking Water)

This definition means that if you serve water from your own source (well or surface intake) to 25 or more people per day, or have 15 or more service connections, and operate for 60 or more days per year, you are operating a public water system. There are three types of public water systems and each is regulated differently. The three types are:

Community Public Water System:
A public water system which serves at least fifteen service connections used by year-round residents or regularly serves at least 25 year-round residents. (Year- round is defined as permanent residence greater than six months.) Examples include water utilities, mobile home parks, apartment buildings, nursing homes.

Non-Transient, Non-Community Public Water System:
A non-community public water system that serves at least 25 of the same persons for six months or more per year. Examples include schools, office buildings, factories.

Transient Public Water System:
A non-community public water system that serves at least 25 persons, but not necessarily the same persons, for at least 60 days per year. Examples include restaurants, camps and campgrounds, motels and hotels, and bottled water companies.

"New Well" is defined as a well that has not been drilled yet or an existing well that has not been regulated as a public water source in the last five (5) years… new to the Maine Drinking Water Program *(this includes After the Fact wells)*.

If you are planning a new well for a new or existing **Transient Public Water System**, the materials you need for well and system approval are within this application, or referred to in this application. If you are planning a well for a community or a non-transient, non-community system, please request the appropriate application from the Drinking Water Program (DWP), or see the DWP website: www.medwp.com

Please contact the Drinking Water Program at (207)-287-2070 if you have any questions concerning the process for reviewing an application for a new well or a new public water system. Compliance of the entire public water system will be evaluated during a comprehensive inspection by the Drinking Water Program.

GETTING APPROVAL FOR A TRANSIENT PUBLIC WATER SYSTEM OR WELL

If you own or operate a public water system in Maine, or are planning to establish one, drilling and utilizing a new well for serving water to the public requires written approval from the Maine Drinking Water Program (DWP) in the Department of Health and Human Services. This application has the material you need to complete this process.

Every public water system has a primary point of contact with the Maine Drinking Water Program:

- **PWS Inspector**… responsible for helping you to complete the new well and system approval process, all aspects of inspecting your public water system, for evaluating water quality and overall compliance of your public water system with the Maine Rules Relating to Drinking Water. Your PWS Inspector contact information is on the front cover of this publication.

STEPS OF THE NEW WELL AND SYSTEM APPROVAL PROCESS

1. Fill in the "Facility Information and Points of Contact" form.
2. Fill in the "Request for Preliminary Well/System Approval" form. Note that public water system wells must be 300 feet from leachfields and 1000 feet from underground storage tanks. See setback waiver policies at www.medwp.com
3. Fill in the "Potential Sources of Contamination" form.
4. Provide (sketch) a "Site Plan for Preliminary Approval of the Proposed Well". A sample is provided in this packet

Send items 1-4 to your PWS Inspector, identified on the front cover of this publication.

5. After Preliminary Approval has been granted by the PWS Inspector, the well can then be drilled. (For a system with an existing well, after preliminary approval is granted, proceed to the next step)
6. Work with the PWS Inspector to arrange required water quality tests to be collected.
7. Fill in the "Request for Final Well/System Approval" form.
8. Fill in the "Water System Component Checklist and Questionnaire".

Send items 7-8 to your PWS Inspector.
Note: If your public water system is already in operation serving water to the public, complete items 1 through 8 and send all materials to your PWS Inspector.

9. After Final Well/System Approval is granted, contact the PWS Inspector when water is being served to the public from this new well or new public water system.

Public Water System Points of Contact Change Form

Person Completing this form:		Date:	
Public Water System Name:		PWSID#:	
Person providing information:		New owner?	

☐ **Change of single address only**. Enter data for this POC change of address. Leave the other boxes blank.

☐ **Change of POC or multiple address changes.** All boxes must be completed. Add additional boxes if necessary. If a Point of Contact (POC) has no change just check the "No Change" box. Do not fill out the rest of the information. If a person is more than one type of POC, type "same as ____" in the name field.

Administrative Contact (AC)	☐ No Change		
Name:		Fax (Dedicated line):	
Mailing Address:		Emergency Phone:	
City, State, Zip Code:		E-mail:	
Phone:			
Emergency Contact (EC)	☐ No Change		
Name:		Fax (Dedicated line):	
Mailing Address:		Emergency Phone:	
City, State, Zip Code:		E-mail:	
Phone:			
Financial Contact (FC)	☐ No Change		
Name:		Fax (Dedicated line):	
Mailing Address:		Emergency Phone:	
City, State, Zip Code:		E-mail:	
Phone:			
Owner (OW)	☐ No Change		
Name:		Fax (Dedicated line):	
Mailing Address:		Emergency Phone:	
City, State, Zip Code:		E-mail:	
Phone:			
Sampling (SA)	☐ No Change		
Name:		Fax (Dedicated line):	
Mailing Address:		Emergency Phone:	
City, State, Zip Code:		E-mail:	
Phone:			
Designated Operator (DO)	☐ No Change		
Name:		Fax (Dedicated line):	
Mailing Address:		Emergency Phone:	
City, State, Zip Code:		E-mail:	
Phone:			
Please indicate which if any this DO replaces:			
Use the "Other" boxes below to add additional DO			
☐ Confirmation from Operator Licensing Staff Received			
Operator (OP)	☐ No Change		
Name:		Fax (Dedicated line):	
Mailing Address:		Emergency Phone:	
City, State, Zip Code:		E-mail:	
Phone:			
Please indicate which if any this OP replaces:			
Use the "Other" boxes below to add additional OP			
Other (indicate type of POC)			
Name:		Fax (Dedicated line):	
Mailing Address:		Emergency Phone:	
City, State, Zip Code:		E-mail:	
Phone:			
Please indicate the POC that this person replaces if applicable:			
Other (indicate type of POC)			
Name:		Fax (Dedicated line):	
Mailing Address:		Emergency Phone:	
City, State, Zip Code:		E-mail:	
Phone:			
Please indicate the POC that this person replaces if applicable:			

Note: Whoever makes these changes to SDWIS must print out this form and send it to the PWS file. (DWP0185-F)

REQUEST FOR PRELIMINARY APPROVAL
FOR A TRANSIENT PUBLIC WATER SYSTEM OR WELL

Note: Preliminary approval is required **before** a well is drilled.

NOTE THAT A NEW WELL MUST BE DRILLED BY A WELL DRILLER LICENSED IN THE STATE OF MAINE. FOR A LIST OF WELL DRILLERS, CONTACT THE MAINE WELL DRILLING COMMISSION AT (207) 287-5699

Facility Name: ___________________________________
PWSID# (if an existing public water system): _____________
Contact Name: ___________________________________
Town or City: ____________________________________

This application is for (check one):
☐ An additional or new well for an existing public water system?
☐ A well for an existing facility which has not been regulated before?
☐ A well for a proposed facility which has not yet been constructed?

Allow 30 Days for Processing

I plan to drill the well by __________(date). I want to have it on-line by __________ (date)

This application will be returned unless accompanied by:

1. A location map (an “X” drawn on a map from the Maine Altas and Gazateer is sufficient)
2. A site plan (more detailed map of the well site) including:
   - A scale (1inch = 100 feet or similar)
   - All potential contaminant sources (leach fields, fuel tanks etc.) within 300 feet of the well.
   - Underground Storage Tanks within 1000 feet of the well.
   - Surface water bodies (lakes, streams, ponds) within 300 feet of the well.
   - Property boundries and the land uses on adjacent properties
   - The general slope of land near the well
3. A copy of HHE 200 septic system design form if a leach field is within 300 feet of the well.

ESTABLISHMENT DESCRIPTION

CHECK ALL THAT APPLY:	NUMBER OF:
☐ Restaurant	____ seats ____ meals per day ____ employees
☐ Hotel or Motel	____ units
☐ Campground	____ units
☐ RV Park	____ sites
☐ Children’s Camp	____ campers and staff
☐ Other (describe) : ____	

If a Take-Out eating establishment, check the services that will be provided using water from the well: ☐ Fountain soda ☐ Coffee ☐ Slush drinks ☐ Cup dispenser in bathroom ☐ Drinking Water fountain

Is this a seasonal operation? ________ If yes, season begins? _________ season ends? ________

How many feet away is the nearest property line? ____________(feet)
How much land is controlled and/or owned? ________________ (acres)
How many feet to the nearest corner of any leachfield? _________(feet). *Setback waiver is required if less than 300 feet*
How many feet to the nearest underground storage tank? _______(feet). *Setback waiver is required if less than 1000 feet*

CERTIFICATION: I hereby certify that, to my knowledge, the information on this form and attachments is true and accurate and no site details have been omitted which would have a bearing on the suitability of the site for installation of a public water supply well. **Maine law makes it illegal for persons applying for a Departmental permit to make false statements upon an application with the intent to deceive department officials in the course of their official duties, or to create a false impression in a written application for pecuniary or other benefit. Unsworn Falsification is a Class D misdemeanor offense punishable by up to 364 days incarceration, a fine of up to $2,000, or both.**

Signature: ___________________________________ Title ______________________________________
Print Name ___________________________________ Date ______________________________________

FOR OFFICE USE ONLY: PWS Inspector ______________________________ Population Estimate: _____________
Date this form was received ______________Source ID Number _____________ Date of site visit __________________
Will a Setback Reduction Waiver be required? _______ If yes, use Setback Waiver Form. New PWSID# needed? _______
If yes, Unique or Parent/Child? ________________ Is the system Active (A) or Proposed (P) at this time? _____________

POTENTIAL SOURCES OF CONTAMINATION (PSC), CURRENT OR PAST

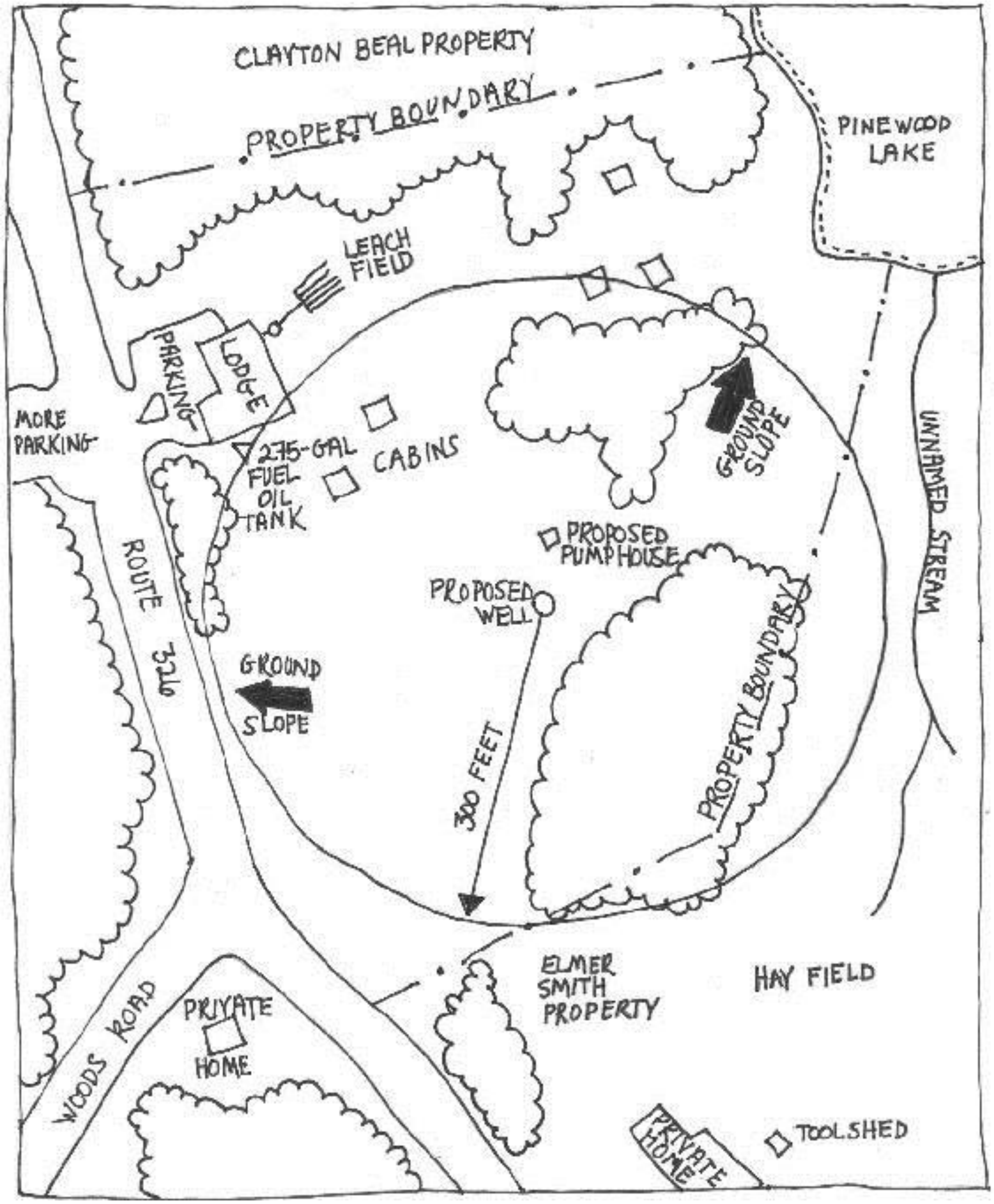
PWS Name____

PWSID#___________________________**Date:**___________________

PWS Inspector Name____

Number of PSCs	Land Use Activity	Distance to well	Number of PSCs	Land Use Activity	Distance to well
	HERBICIDE / PESTICIDE USE		**OTHER**		
	1. Agricultural chemical spreading or spraying			50. Abandoned well	
	2. Agricultural chemical storage			51. Boat builder, refinisher, maintenance	
	3. Bulk grain storage			52. Chemical reclamation	
	4. Chemically fertilized agricultural field			53. Food processor	
	5. Golf course			54. Graveyard & cemetery	
	6. Herbicide sales or applicator			55. Heat treater, smelter, annealer, descaler	
	7. Nursery or garden shop			56. Incinerator	
	8. Pesticide sales or applicator			57. Industrial discharge	
	9. High voltage transmission lines			58. Industrial manufacturer	
	PETROLEUM / HYDROCARBON USE (VOCS OR SEMI-VOCS)			59. Industrial waste disposal	
	10. Aboveground oil storage tank (including home heating oil tanks)			60. Landfill, dump, transfer station	
	11. Underground oil storage tank			61. Metal plating	
	12. Airport fueling area			62. Military facility	
	13. Airport maintenance			63. Monitoring well	
	14. Auto chemical supply wholesaler			64. Railroad yard or line	
	15. Auto repair			65. Recycling or processing center *(other than beverages)*	
	16. Body shop			66. Research laboratory	
	17. Concrete, asphalt, tar, coal company			67. Residential home	
	18. Dry cleaner			68. Rust proofer	
	19. Furniture stripper			69. Salt pile or sand & salt pile	
	20. Gas station, service station			70. Septic system, septic waste disposal	
	21. Junk or salvage yard			a. Beauty parlor	
	22. Machine shop			b. Car wash	
	23. Oil pipeline			c. Laundromat	
	24. Painters, finisher			d. Medical, dental, veterinarian office	
	25. Parking lot			e. Mortuary/ funeral parlor	
	26. Photo processor			f. Multi-unit housing	
	27. Printer			g. Single-family housing	
	28. Sand & gravel mining, other mining			h. Other_________________________	
	29. Small engine repair shop			71. Sewer line	
	30. Snow dump (large commercial or municipal)			72. Sludge disposal or spreading	
	31. Stormwater impoundments or run-off area			73. Wastewater impoundment area	
	32. Truck terminal			74. Wastewater treatment plants, discharge	
BACTERIA AND INORGANICS	**SUCH AS NITRATES / NITRITES**			75. Wood preserver	
	40. Animal burial (large scale site)			76. Other – Please indicate other potential contamination sites not included in this list. __________________________	
	41. Animal grazing				
	42. Barnyard				
	43. Manure pile				
	44. Manure spreading				
	45. Meat packer, slaughter house				
	46. Municipal wastewater plant				

EXAMPLE OF A SITE PLAN FOR PRELIMINARY APPROVAL OF PROPOSED WELL



An acceptable site plan must include:

- A scale (1inch = 100 feet or larger);
- Potential sources of contamination within 300 feet (leach field, fuel tank, etc.);
- Underground Storage Tanks within 1000 feet of the well;
- Property boundaries;
- A description of land uses on adjacent properties;
- The general slope of land near the well; and
- Surface water bodies within 300 feet of the well.

TRANSIENT PUBLIC WATER SYSTEM
APPROVAL PROCEDURE FOR A NEW SYSTEM OR WELL
WATER QUALITY TESTING REQUIRED FOR FINAL APPROVAL

Transient public water systems serve a constantly changing population of one-time or infrequent customers. Examples include restaurants, motels, parks, campgrounds and summer camps. After a well is drilled it must be developed per the Maine Rules Relating to Drinking Water, Section 3 (G)(2)(a) and shock chlorinated. Continue to pump the well until the odor of chlorine can no longer be detected (if there is still chlorine in the water when it reaches the lab, the test for coliform bacteria will be invalidated and will need to be taken again). At the conclusion of the well development and disinfection, take samples for the following tests. Final approval of a well requires satisfactory results from these tests.

1. Total coliform bacteria, nitrate, and nitrite.

2. Fluoride, chloride, hardness, antimony, iron, pH, manganese, uranium, arsenic.

3. If within 1000 feet of the well an underground fuel storage tank exists or a fuel spill has occurred, a volatile organics water test must be completed.

For a list of labs certified by the State of Maine, contact the Drinking Water Program at (207) 287-2070. To order bottles from the State Health Lab, call the PWS Inspector listed on the front page of this application.

The Maine Rules Relating to Drinking Water can be found at www.medwp.com

REQUEST FOR FINAL APPROVAL OF A TRANSIENT PUBLIC WATER SYSTEM OR WELL

WELL CONSTRUCTION INFORMATION

Facility Name____
PWSID#____
Town or City____
On-site Contact____
On-site Phone____

WATER TEST RESULTS MUST ACCOMPANY THIS FORM.

COMPLETE FOR WELLS:		**COMPLETE FOR BEDROCK WELLS:**	**COMPLETE FOR GRAVEL WELLS:**
Name & Address of Well Driller:	**Required Water Tests**: ☐ Total coliform bacteria, nitrate, nitrite ☐ Fluoride, chloride, hardness, antimony, iron, pH, manganese, uranium, arsenic ☐ VOC if applicable	Date drilled:	Date drilled:
		Total depth:	Total depth:
Driller's License #:		Depth to bedrock:	Depth to top of screen:
Pump test duration (hours):		Length of casing:	Length of screen:
Water tests must be conducted by a certified laboratory. If you choose to use the State Health and Environmental Testing Laboratory, call the PWS Inspector (see front page this packet) to order sample bottles. If you chose to use a private certified laboratory, enter name of certified laboratory here:________________________________		Diameter of casing:	Diameter of casing:
		Safe Yield (GPM):	Safe Yield (GPM):

CERTIFICATION

I hereby certify that, to my knowledge, the information on this form and attachments is true and accurate. I certify that the well has been drilled as specified on the preliminary approval request submitted earlier and that water test results are from raw water samples taken from the well described above. **Maine law makes it illegal for persons applying for a Departmental permit to make false statements upon an application with the intent to deceive department officials in the course of their official duties, or to create a false impression in a written application for pecuniary or other benefit. Unsworn Falsification is a Class D misdemeanor offense punishable by up to 364 days incarceration, a fine of up to $2,000, or both.**

Signature_______________________________ Title___________________________________

Print Name______________________________ Date___________________________________

Attach copies of water quality test and return to the PWS Inspector identified on the front cover of this packet.

Allow 30 days for processing.

FOR OFFICE USE ONLY	
SOURCE ID NUMBER	
DATE RECEIVED	
DATE APPROVED	
CONDITIONAL?	

Water System Component Checklist & Questionnaire

The well approval procedure focuses primarily on the water source and the physical well itself. Compliance of the entire water system will be evaluated during a comprehensive inspection completed by the Drinking Water Program. Please check off the components that are, or will be, part of the water system. Include notes as needed.

Facility Name: ____ Date: ____________

☐ Submersible well pump

☐ Above-ground suction well pump

☐ Bladder pressure tank(s)
Qty _________________
Size(s) (gal) __________

☐ Hydropneumatic pressure tank
Size (gal): ___________

☐ Atmospheric storage tank & pump
Size (gal): ___________

☐ Gravity storage tank
Size (gal): ___________

☐ Sediment filter
Type: ____

☐ Water meter

☐ Treatment (please specify):
____
____
____
____

What is supplied by this water system (buildings/units/etc.)?
____
____
____

Other water system information:
____
____
____
____
____

APPENDIX D

General Steps of a Hydrogeologic Assessment

(Page 9 of the following attachment)

Department of Health
and Human Services
Maine People Living
Safe, Healthy and Productive Lives

Department of Health and Human Services
Maine Center for Disease Control and Prevention
286 Water Street
11 State House Station
Augusta, Maine 04333-0011
Tel: (207) 287-2070; Fax: (207) 287-4172
TTY Users: Dial 711 (Maine Relay)

PURPOSE FOR NEW POLICY/PROCEDURE: This policy is written to provide detail for administering the Maine Rules Relating to Drinking Water regarding the issuance of well to contamination source setback waivers. For setback requirements related to Underground Storage Tanks (USTs), see DWP0057.

ORIGINATOR/OWNER: Nathan Saunders P.E.

POLICY: Well-to-Contamination Source Setback Waiver Policy for Public Water Systems

DEFINTIONS:

Certified Geologist: A Maine Certified Geologist

Contamination Source: Leach field or other significant contamination source, not including an Underground Storage Tank (UST). For setback requirements related to Underground Storage Tanks (USTs), see DWP0057.

Existing Well: an existing well is a well already drilled when an establishment first approaches the Drinking Water Program to identify requirements related to becoming a PWS. If after contacting the DWP to identify applicable regulations and requirements, a system drills a well without DWP approval, this drilled well will not be eligible for waiver opportunities afforded to an “existing well”. Understanding this, it is essential that DWP personnel record the date of new system/well related conversations with a prospective public water system or a public water systems seeking to add a well. ***Note:*** *A well driller drilling a well at an establishment meeting PWS criteria without prior approval from the DWP will be considered for referral to the Well Driller’s Board.*

Licensed System: any system with a state license such as a day care, nursery school, convenience store, restaurant, campground, etc.

New Well: defined as a well that has not been drilled yet or an existing well that has not been regulated as a public water source in the last five (5) years… new to the Maine Drinking Water Program (*this includes After the Fact wells).*

Replacement Well: a well that provides a new source of water to a population served by an existing, currently regulated PWS well (which no longer serves the PWS). A replacement well is **not** a redundant or an additional well and may be an existing well. In the case of a well whose volume capacity has diminished over time, an additional well that replaces the lost capacity will be considered a “replacement” well (replacing lost capacity) and the existing, reduced-capacity-well may continue to be used; the reduction in volume capacity must be proven and documented.

WT-IS Policy: Water Testing for Non-Community Public Water Supply Wells with Inadequate Setbacks from Septic System Disposal Leach Fields (DWP0072).

REGULATIONS:

From the Maine Rules Relating to Drinking Water [10-144 CMR 231 (3)(G)(2)]

1. "New wells shall be located at least 300 feet away from potential contamination sources" [primarily septic system leach fields]

2. "If circumstances exist where a proposed well location must be placed closer than 300 feet from a potential contamination source, [e.g. septic system leach field], then the Department may grant a setback waiver on a case-by-case basis."

Public water system owners may be granted a waiver if the following circumstances prevent a 300-foot setback: These circumstances are incorporated directly from Chapter 4 of the Well Drillers Rule, CMR 232, New Water Well Construction.

a) the size of the property is not sufficient to allow for the required setback; or
b) sufficient setbacks from other potential sources of contamination cannot be met; or
c) excessive slopes prohibit access; or
d) the location of permanent structures would result in unreasonable impacts or damage to the structures; or
e) the location of lakes, ponds, streams or wetlands prohibits meeting the required setback; or
f) the presence of bedrock at or within three vertical feet of the surface would result in unreasonable trenching requirements; or
g) other requirement as accepted by the Maine Drinking Water Program (DWP) staff.
h) the new well is a "Replacement Well" as defined by this policy.

SPECIAL WAIVERS FOR STATE-LICENSED SYSTEMS:

Establishments meeting the DWP criteria of a public water system, currently licensed by another State agency (day cares, nursery schools, conveniences stores, restaurants, etc.), and operating continuously from before July 1st, 2009 until present, will be granted a well-to-leach field setback waiver if their separation distance measures between 100 and 300 feet. Such establishments with a well-to-leach field separation distance less than 100 feet will be evaluated for a setback waiver on a case-by-case basis. In contrast, all public water system establishments that began or substantially changed their licensed operation after July, 1st, 2009 will be subject to the standard requirements of this policy. All establishments with a setback less than 300 feet are required to sample according to the policy (DWP0072) for Water Testing for Non-Community PWS with Insufficient Setbacks from Septic System Disposal Leach Fields (WT-IS).

EXISTING WELLS

Existing wells, defined above, may be eligible for a setback waiver. See Standard Policy below.

REPLACEMENT WELLS

A "replacement" well, as defined above, may be issued a setback waiver without requiring a hydrogeologic assessment (Apdx B).

For a well drilled to replace a contaminated well (due to oil or other contaminant), additional testing and/or a hydrogeologic assessment (Apdx B) may be required.

A well that makes up (replaces) the lost volume capacity of a well with diminished output can only be considered a “replacement” well if the diminished output of the well is proven and documented. A well that cannot meet an increased demand does not qualify as a well with diminished output. Therefore, if the growth of a PWS increases the demand on an existing well and the well cannot meet the increased demand, then an “additional” well is required and it cannot be considered a “replacement” well.

Note: when drilling a replacement well close to an existing well, the well-driller/owner should take caution if abandoning the existing well so that the abandonment process does not negatively impact the new well. For example, do not fill up the entire existing well with Bentonite slurry. Instead, fill the well with crushed rock to within 10 to 20 feet of the casing shoe, then fill the remaining well and casing with Bentonite slurry.

Due to the hydrogeologic complications associated with drilling a replacement well close to an existing well, setback waivers for replacement wells need to be reviewed and signed by the DWP Geologist.

STANDARD POLICY

The Well to Contamination Source Setback Waiver Form (DWP0150) must be used to record a setback waiver request that is granted or denied.

Setback = 300 feet or more:

If a setback measures 300 feet or more, then a waiver is not required. Tables (1) and (2) within the Policy for Water Quality Monitoring for Non-Community PWS Wells with Inadequate Setbacks from Septic Disposal System Leach Fields (WQM-IS) offer monitoring and well construction guidance for Non-Community public water systems. Monitoring and well construction requirements for Community systems are determined on a case-by-case basis.

Setback = 150 to 299 feet:

1. A public water system seeking to drill a new well must meet one of the above 8 circumstances that prevent a 300-foot setback from occurring. If none of the above circumstances apply, then the public water system must create a 300-foot-or-greater setback by drilling a well, moving a septic system leach field, or some other method.

2. A public water system seeking to drill a new well with a setback of 150 to 299 feet, that fails to meet one of the reduced-setback circumstances, may hire a certified geologist to render an opinion concerning the risk of the well being contaminated by the leach field, based on the surficial geology between the well and the leach field. A setback of 150 to 299 feet may be waivered by a DWP geologist upon review of the information, data, and opinion provided by a certified geologist. Potential remedies to this reduced setback include septic pretreatment and/or well modification (e.g. installation of a Jazwell seal of an appropriate length), as approved by a DWP geologist. See Appendix B: General Steps of a Hydrogeologic Assessment

3. For an existing well that fails to meet one of the above 8 circumstances allowing for a reduced setback, the DWP may issue a setback waiver.

4. A waivered non community public water system with a setback between 150 to 299 feet must follow the water quality monitoring and well construction requirements from Table 1 and Table 2 of the WT-IS Policy. Monitoring and well construction requirements for Community systems are determined on a case-by-case basis.

Setback = 100 to 149 feet:

1. A public water system seeking to drill a new well must meet one of the above 8 circumstances that prevent a 300-foot setback from occurring. If none of the above circumstances apply, then the public water system must create a 300-foot-or-greater setback by drilling a well, moving a septic system leach field, or some other method. See definition of an existing well.

2. A public water system with a setback of 100 feet to 149 feet that requires a hydrogeologic assessment may only receive a waiver if a DWP geologist reviews and approves such a waiver request.

3. For both an existing well or a well that has not been drilled yet, a public water system that started operating or was substantially changed after 10/24/2001, per the Maine Rules Relating to Drinking Water:

> Must complete a hydrogeologic assessment appropriate to the system classification and situation as specified by a DWP geologist. The DWP geologist will approve or disapprove the evaluation. DWP Field Inspectors will instruct the public water system to contact a DWP geologist to discuss the requirements of a hydrogeologic assessment. If the DWP Geologist determines that a professional hydrogeologic assessment is necessary, the assessment must be completed by a Maine Certified Geologist. **A hydrogeologic assessment may be waived if a certified geologist submits an engineered septic and/or well construction proposal that is then approved by the DWP.** See Appendix B: General Steps of a Hydrogeologic Assessment

4. A public water system that started operating or was substantially changed before 10/24/2001, with a well(s) drilled before 10/24/2001, is not required to complete a hydrogeologic assessment for that well. Note water quality monitoring requirements below.

> **Note:** A waiver of the hydrogeologic assessment based on the age of the system is only applicable for wells drilled before 10/24/2001. Conversely, any well drilled after 10/24/2001 must be evaluated using a hydrogeological assessment.

5. A waivered non community public water system with a setback between 100 to 149 feet must follow the water quality monitoring and well construction requirements from Table 1 and Table 2 of the WT-IS Policy. Monitoring and well construction requirements for Community systems are determined on a case-by-case basis.

Setbacks less than 100 feet:

1. A public water system seeking to drill a new well must meet one of the above 8 circumstances that prevent a 300-foot setback from occurring. If none of the above circumstances apply, then

the public water system must create a 300-foot-or-greater setback by drilling a well, moving a septic system leach field, or some other method.

2. A public water system with a setback of less than 100 feet that requires a hydrogeologic assessment may only receive a waiver if a DWP geologist reviews and approves such a waiver request.

3. For an existing well, a hydrogeologic assessment is required, regardless of the establishment start date or substantial change date.

4. For both an existing well or a well that has not been drilled yet, per Maine Rules Relating to Drinking Water, any system that started operating or was substantially changed after 10/24/2001 must complete a hydrogeologic assessment as specified above for setbacks of 100 to 149 feet. **A hydrogeologic assessment may be waived if a certified geologist submits an engineered septic and/or well construction proposal that is then approved by the DWP.** See Appendix B: General Steps of a Hydrogeologic Assessment

5. A waivered non community public water system with a setback less than 100 feet must follow the water quality monitoring and well construction requirements from Table 1 and Table 2 of the WT-IS Policy. Monitoring and well construction requirements for Community systems are determined on a case-by-case basis.

Approval of Setback Waivers

The DWP Field Inspection Team Manager can approve and sign setback waivers that do not require a hydrogeologic assessment. All waivers that require a hydrogeologic assessment must be approved and signed by a DWP Geologist.

Associated Documents

Well to Contamination Source Setback Waiver Form (DWP0150)
New System or Well Approval Procedure (DWP0068)
Well-to-Underground-Storage-Tank (UST) Setback Policy for Public Water Systems (DWP0057)
Water Quality Monitoring for Non-Community PWS with Insufficient Setbacks from Septic System Disposal Fields: [WT-IS Policy] (DWP0072)

Superseded Documents

None

Retention

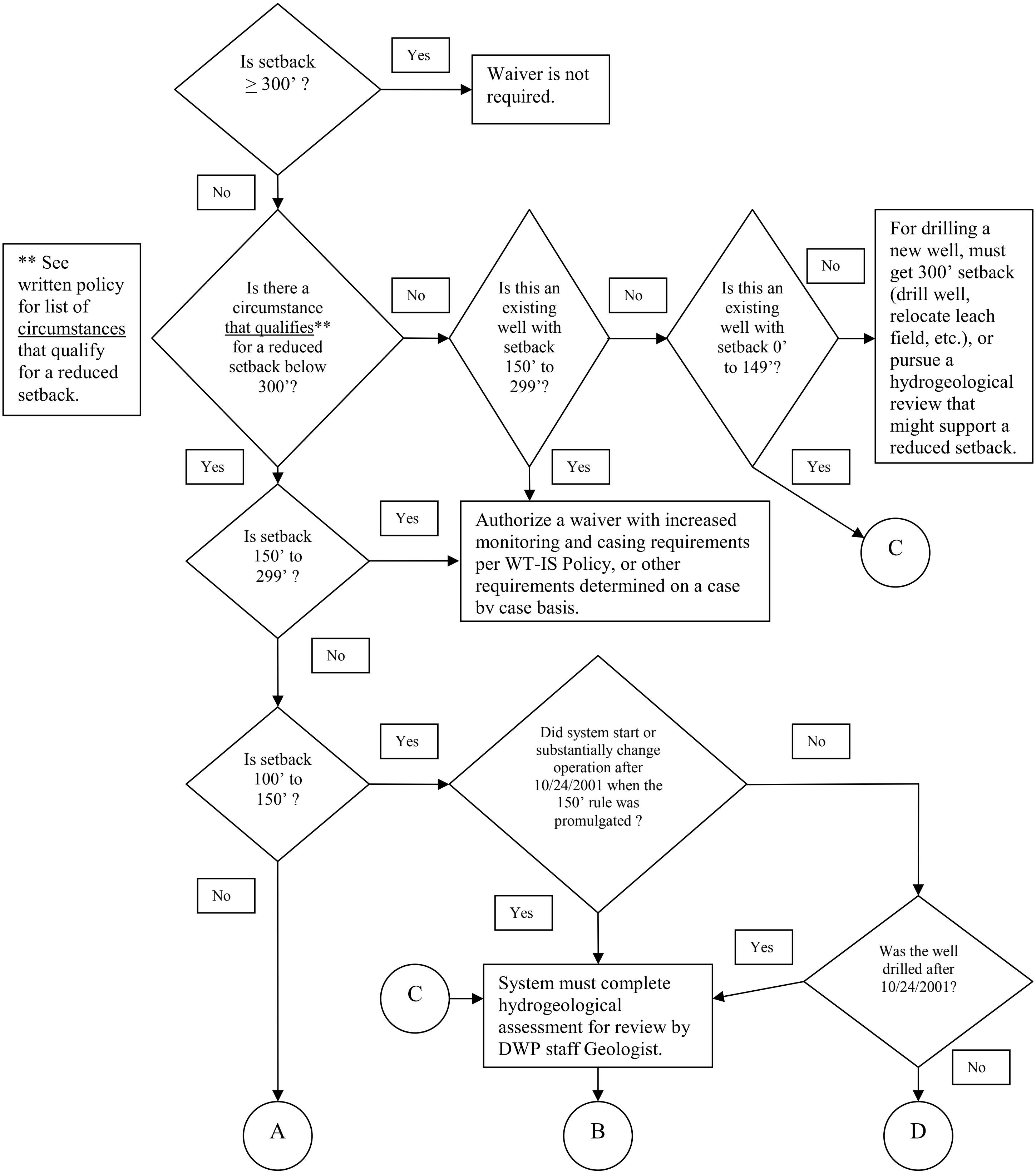
This document is retained per the DWP Record Retention Procedure

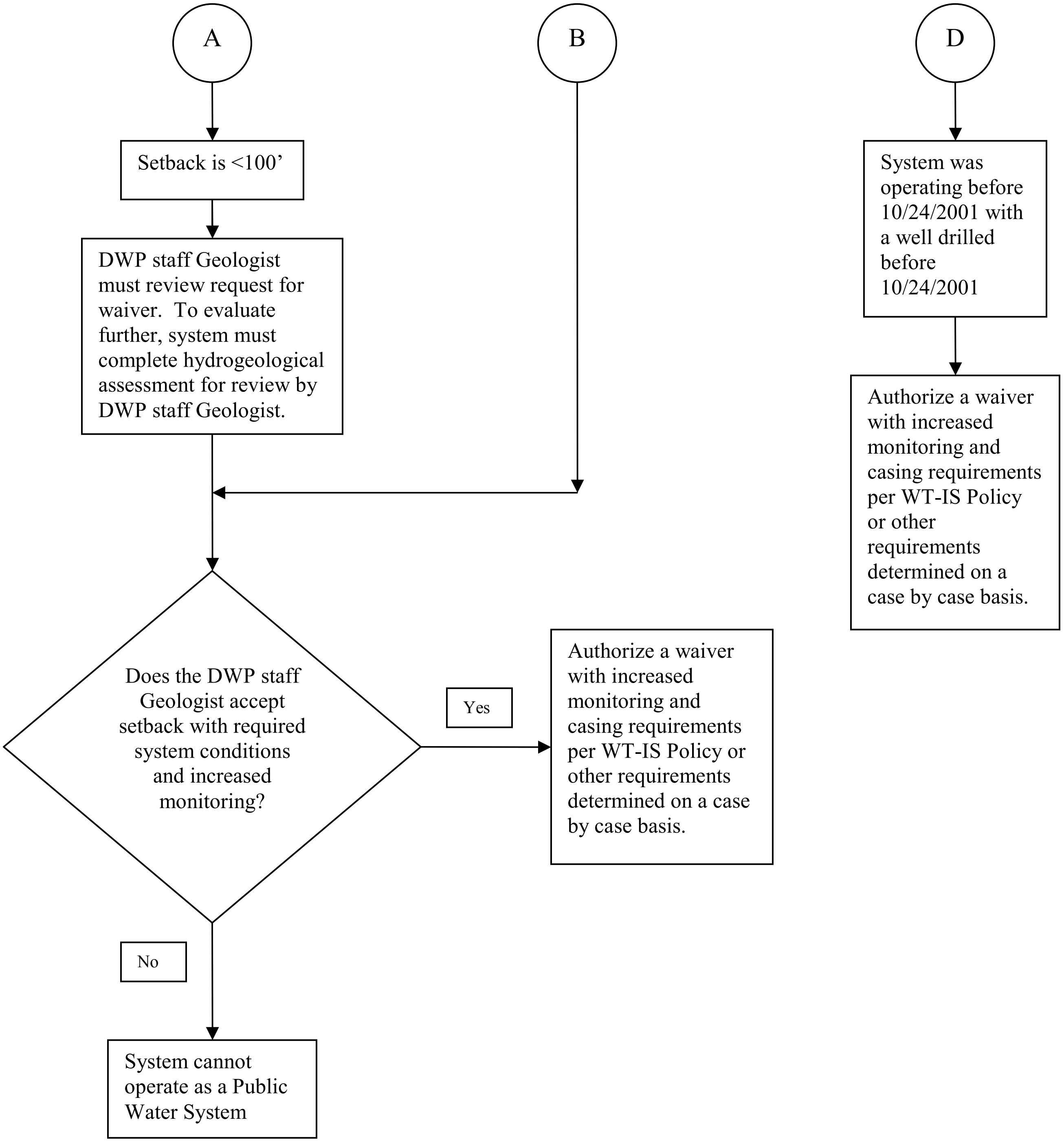
Revision Log

Section	Page	Rev.	Date	Description Of Change	Approved by:
		Original	9/25/06		Nancy Beardsley
		B	1/9/07		Nancy Beardsley
Policy		C	5/11/09	Changed wording of Maine rules to reflect updated rules. Added criteria for state licensed establishments. Reformatted to meet DWP documentation requirements. Used “Certified Geologist” throughout doc.	Roger Crouse
Special Waivers	2	D	8/3/09	Added clarifying language	Roger Crouse
Definitions, Policy	Several	E	4/16/10	Added definition and policy on “Replacement Wells”	Roger Crouse
Definitions Policy	Several	F	8/19/11	Added definition and policy on “Existing Wells”. Clarified waivering a hydrogeologic assessment for systems in place before 10/24/2001.	Roger Crouse
Purpose, Policy, Apdx	Several	G	8/23/12	Referred to UST policy in Purpose. Removed Apdx B - waiver form, to its own document (DWP0150). Changed Apdx C to B.	Nathan S. Saunders Nathan Saunders
Definitions, Appndx A	1,7	H	10/22/2013	Changed New Well Definition from 3 to 5 years. Clarified flow chart on drilling a new well with no reason for a setback reduction, to match written policy in “Standard Policy, Setback = 150 to 299 feet, bullet 2, on page 3.	Nathan S. Saunders Nathan Saunders

Appendix A

Flowchart for the Well to Contamination Source Setback Waiver Policy for Public Water Systems




A
B
D
Setback is <100’
DWP staff Geologist must review request for waiver. To evaluate further, system must complete hydrogeological assessment for review by DWP staff Geologist.
Does the DWP staff Geologist accept setback with required system conditions and increased monitoring?
Yes
Authorize a waiver with increased monitoring and casing requirements per WT-IS Policy or other requirements determined on a case by case basis.
No
System cannot operate as a Public Water System
System was operating before 10/24/2001 with a well drilled before 10/24/2001
Authorize a waiver with increased monitoring and casing requirements per WT-IS Policy or other requirements determined on a case by case basis.

Appendix B
General Steps of a Hydrogeologic Assessment

When a hydrogeologic assessment is either required or requested as part of a setback waiver request:

1. The DWP Field Inspector contacts DWP Geologist to provide known site related information.
2. The DWP Geologist determines if enough information is known to justify a setback waiver, and also potentially to waive a formal hydrogeologic assessment.

    - If enough information is known that justifies a setback waiver, the field inspector fills out the Well to Contamination Source Setback Waiver Form (DWP0150) and sends it to the DWP Geologist to record any necessary waiver conditions and to sign the waiver. The waiver is granted. (see note below).

    - If not enough information is known to justify a setback waiver, the field inspector informs the PWS that they must hire a Maine Certified Geologist to complete a hydrogeologic assessment. The PWS can call the DWP Geologist to discuss the hydrogeologic assessment process. The hired geologist should first call the DWP Geologist to discuss the specific geological conditions at the site. It is possible that due to unfavorable geological conditions, further geological study is not warranted (see note below), and subsequent effort should be focused on acceptable risk mitigation such as drilling a new well or installing septic pretreatment. This may occur without requiring the cost of a detailed hydrogeologic assessment and report. It is also possible that further hydrogeologic assessment will record that geologic conditions warrant a waiver, with or without well construction requirements. In this case a report from a Certified Maine Hydrogeologist must be submitted to the DWP Geologist for review and approval, or disapproval. If the hired geologist is in contact with the DWP geologist about findings and options developed during the study, the assessment should end up identifying a best plan for acceptable risk mitigation, which reduces the chance of a plan simply being denied.

      Note: The Maine Rules Relating to Drinking Water give the opportunity for the DWP to waive the request for a hydrogeologic assessment from a Maine Certified Hydrogeologist