J-4

City of Bozeman Sanitary Landfill

Groundwater Monitoring and Evaluation Report

City of Bozeman
Contract No.
417-018-02-00-46

HDR Project No.
07179-001-164

January 1991

Morrison Maierle/CSSA Inc.

HDR

HDR Engineering, Inc.

PHASE I and PHASE II

GROUNDWATER MONITORING EVALUATION REPORT

CITY OF BOZEMAN SANITARY LANDFILL

Prepared by:

Morrison-Maierle/CSSA, Inc.

and

HDR Engineering, Inc.

Prepared for:

City of Bozeman, Montana

January 1991

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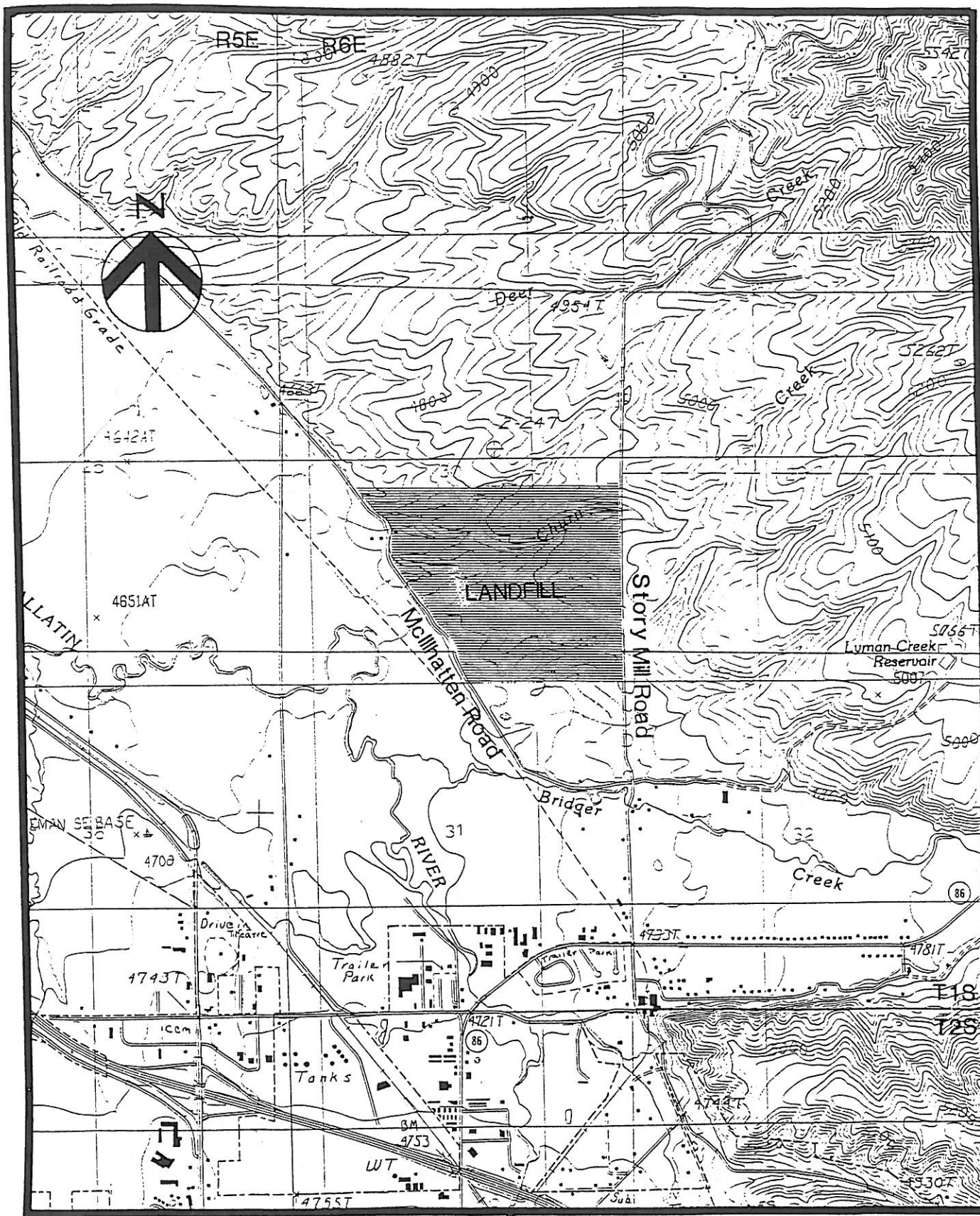
INTRODUCTION

The City of Bozeman Sanitary Landfill (Landfill) is located approximately two miles northeast of Bozeman, Montana in the southeast 1/4 of the southwest 1/4 of section 30, Township 1 south, Range 6 east (Figure 1). The Landfill is owned and operated by the City of Bozeman (City).

Since the Landfill opened in 1969, mixed municipal solid waste composed of residential, commercial, and industrial waste has been accepted. Approximately 105 acres of the original 200 acre parcel have been landfilled to date. Disposal of the refuse has been conducted by the area fill method.

Early hydrogeologic investigations began in 1980 with the installation of several monitoring wells and subsequent sampling and analysis for a limited number of chemical parameters. Investigation continued through 1985 with the installation of additional monitoring wells and continued ground water quality monitoring. Periodic ground water monitoring has continued through the present and a semi-annual sampling schedule has been established.

In October 1989 the Montana Department of Health and Environmental Sciences requested the City of Bozeman address possible environmental degradation at the Landfill with a more in-depth hydrogeologic and ground water quality investigation. Morrison-Maierle/CSSA, Inc. and HDR Engineering, Inc. were jointly contracted to perform a hydrogeologic



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Scale: 1"–2000'

Figure 1
Site Location
Bozeman Sanitary Landfill
Bozeman, Montana

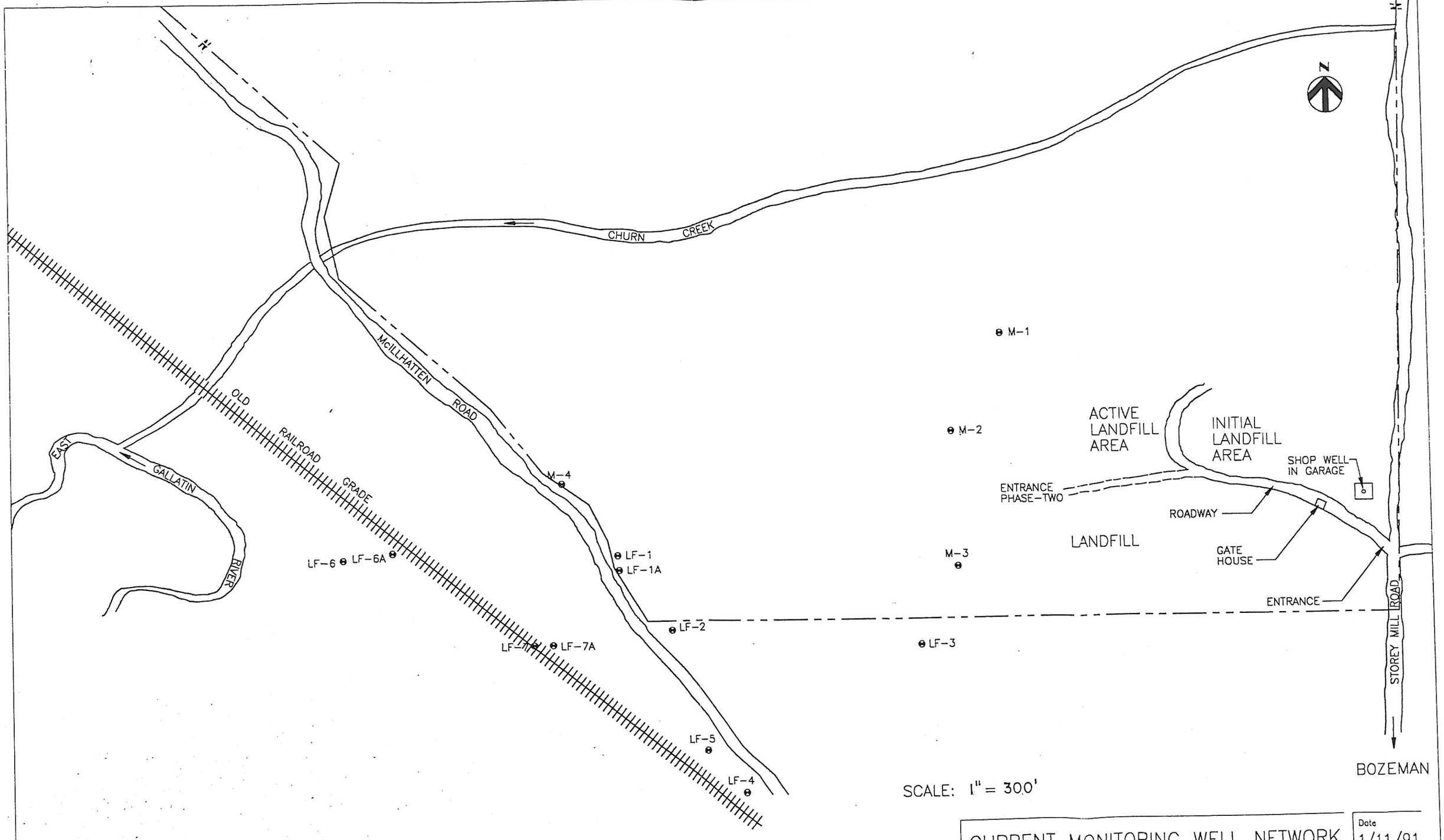
evaluation of the current ground water monitoring system, conduct a sampling event, and develop recommendations for possible improvements to meet the proposed requirements of the Resource Conservation Recovery Act, Subtitle D federal legislation.

The evaluation and investigation was completed to meet the requirements of the Scope of Work (SOW) developed by the City of Bozeman. The SOW outlined three phases of the Landfill evaluation; 1) Ground Water Monitoring Evaluation, 2) Sampling Existing Wells, and 3) Subtitle D Evaluation. Phases I and I are addressed under this report, Phase III is presented under a separate report.

SITE INFORMATION

The Landfill is located on the southwestern slope of the Bridger Mountain Range. Immediately downslope is the East Gallatin River floodplain. McIllhatten Road separates the Landfill and the flood plain of the East Gallatin River. Story Mill Road forms the eastern boundary of the Landfill, while agricultural land borders the north and south (Figure 2). Story Mill Road provides access to the Landfill via County Road 86.

The original topography of the Landfill was hummocky to gently rolling hills. Disposal and subsequent grading has altered the Landfill to a more uniform westerly to southwesterly slope.



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CURRENT MONITORING WELL NETWORK
BOZEMAN SANITARY LANDFILL
BOZEMAN, MONTANA

Date 1/11/91

Sheet FIG.2

Surface drainage is toward the East Gallatin River. Churn Creek and Spring Creek cross the Landfill property in a west to southwest direction and empty into the East Gallatin River. Spring Creek generally has constant flow, whereas Churn Creek is perennial, with flow determined by spring meltwater and heavy precipitation events. Although the creeks are on the Landfill property they do not intersect any existing fill areas and future expansion is not planned in the northern part of the property.

PREVIOUS HYDROGEOLOGIC INVESTIGATIONS

Previous investigations were performed by Hydrometrics, the Soil Conservation Service (SCS), Stiller and Associates (Stiller), and Northern Engineering and Testing Company (Northern). Appendix A contains ground water analysis results collected since 1981 at the Landfill. Data gaps can be attributed to various consultants who have been involved with past assessments of the Landfill and budgetary constraints that have led to infrequent and limited sampling.

The Soil Conservation Service (SCS) initiated the installation of three monitoring wells (M-1, M-2, and M-3) in 1980. In 1982 M-2 collapsed and was replaced with a new well adjacent to the old M-2 (Figure 2).

The monitoring wells, the Clemens and McIllhatten domestic wells, and seeps located downgradient of the Landfill were sampled by a City street crew in November 1981, May 1982, and September 1982, under the

guidance of the SCS, for a limited number of physical and inorganic chemical parameters (Stiller, 1985). The samples were analyzed by the Montana State University Agricultural Department Laboratory (Appendix A).

Sampling was performed at the monitoring wells, downgradient domestic wells, and seeps by a City street crew in May 1983, June 1983, October 1983, May 1984, October 1984, and May 1985, and analyzed at the City Waste Water Treatment Plant Laboratory. The October 1983 sampling event was conducted in the presence of MDHES representatives and included duplicate samples that were analyzed at the MDHES laboratory. MDHES results closely correlated with those of the City (Appendix A).

In January 1985 the Montana Bureau of Mines and Geology installed an additional 10 monitoring wells (LF-1, LF-1A,LF-2, LF-3, LF-4, LF-5, LF-6, LF-6A, LF-7, LF-7A). In October 1985 Stiller and Associates (Stiller) performed a comprehensive evaluation of the existing data to determine data inadequacies relative to ground and surface water quality, monitoring well construction and placement, regional and site hydrogeology, and perform additional ground water quality sampling and analysis. Stiller determined that the ground water quality data collected during the May 1983 through the May 1985 sampling events was most likely invalid due to lack of quality assurance/quality control (QA/QC) techniques in the field and laboratory. In October 1985 Stiller sampled all thirteen monitoring wells and two surface water samples along Churn Creek for a limited number of physical and inorganic chemical parameters (Appendix A). Seeps were not sampled, as

agricultural and livestock runoff into the seep area would most likely bias the sampling. Based upon previously collected ground water data determined to be valid, and data collected by Stiller, it was concluded that although elevated chloride levels were noted, they were not high enough to warrant a serious ground water problem at the Landfill at that time (Stiller, 1985).

Stiller produced a second report in July 1986 as part of continual monitoring effort at the Landfill. An additional downgradient monitoring well was installed (M-4), and a sampling event was undertaken on seven (7) of the monitoring wells (M-1, M-2, M-3, M-4, LF-1, LF-2, LF-3) and the Shop well to further determine if ground water contamination had occurred (Figure 2). Samples taken in 1986 indicate there was relatively little difference in ground water quality since the previous sampling event of 1985 (Appendix A). Decreased chloride levels actually indicated an improvement in overall ground water quality between the 1983 sampling event, when the highest chloride concentrations were observed, and the 1986 sampling event.

Northern performed ground water sampling on seven of the monitoring wells and the Shop well as part of the continual effort to evaluate ground water conditions at the Landfill and determine if a substantial leachate plume had developed. Based upon ground water samples collected from 1981 through 1987, Northern determined that ground water downgradient of the Landfill had been impacted. However, the plume was determined to have stabilized at levels which remain below

National Interim Primary and Secondary Drinking Water Standards established by the Safe Drinking Water Act (Northern, 1987). Primary Standards are established from health-risk based criteria, whereas Secondary Standards are established primarily for aesthetic reasons, such as taste and discoloration.

Morrison-Maierle/CSSA has continued to periodical sample monitoring wells M-1, M-2, M-3, M-4, LF-1, LF-2, and LF-3, and the Shop well from 1987 through 1989 (Figure 2). Although no QA/QC blanks were collected during these sampling events, care was exercised in the field to insure representative ground water samples. All wells were purged and stabilized through measurement of pH, specific conductivity, and temperature, prior to bailing to obtain the sample. All sampling equipment was decontaminated with a ten percent nitric acid solution and rinsed with distilled water to avoid cross contamination between each monitoring well (Morrison-Maierle/CSSA, 1990).

REGIONAL GEOLOGY AND HYDROGEOLOGY

Information was gathered from the Montana State University (MSU) Library, Bozeman Soils Conservation Service (SCS) and the United States Geological Survey (USGS). The majority of the information obtained from the MSU Library and provided by the USGS concerning geology and hydrology in the Bozeman area, dealt with regional features and qualities of the underlying substrate and ground water, rather than site specific or local characteristics of the Landfill.

The following publications were reviewed for regional geologic and hydrologic information:

- 1989 Field Conference Guidebook, Montana Centennial Edition, Montana Geological Society, 1989.
- Bouguer Gravity, Aeromagnetic, and Generalized Geologic Map of the Eastern Part of the Three Forks Basin, Broadwater Madison, and Gallatin Counties, Montana, U. S. Geological Society, 1965.
- Geology and Ground-Water Resources of the Gallatin Valley Gallatin County Montana, U. S. Geological Survey Water-Supply Paper 1482, 1960.
- Hydrology and Geology of Montana State University Campus, Anderson. B., et.al., March, 1982.
- Environmental Geology of the Southeast Margin of the Gallatin Valley, Gallatin County, Montana, Griffith, E.F., M.S. Thesis, Montana State University, 1982.
- Cenezoic Geology and Geomorphology of the Dry Creek Valley, Gallatin County, Montana, Hughes, G.C., M.S. Thesis, Montana State University, 1980.
- Solid Waste Disposal Site Suitability Evaluation in Montana, Bowen, D.W., M.S. Thesis, Montana State University, 1980.

The Field Conference Guidebook and the U. S. Geological Survey publications provided information concerning depth to bedrock, thickness of sediments and the regional ground water patterns. Much of the information contained in these publications was referenced in the University of Montana theses, therefore the theses provided little additional information.

The Landfill is located in the Northern Rocky Mountains physiographic province of the Gallatin River Valley along the East Gallatin River tributary. The Gallatin River Valley is an intermontane valley flanked by the Horseshoe Hills to the north, the Bridger Range to the east and the Madison and Gallatin ranges to the south. The valley

formed as a result of tectonic movement during the Early Tertiary (approximately 50 million years ago), and was subsequently filled with sediment from the adjacent ranges. The Tertiary sediment rest upon the downdropped Precambrian basement rock. The walls of the Gallatin River Valley area are formed by the same Precambrian rock or younger Cambrian through Early Tertiary sequences. The thickness of the Tertiary valley-fill sediments is variable but can approach 6500 feet. Tertiary rock sequences vary in composition from fine, well-sorted siltstones to highly unsorted conglomerates. The competency of the Tertiary sediments is often very low and appear in outcrops as very friable rock, bordering on unconsolidated sediment. This low competency can create problems in determining depth to bedrock during drilling and geophysical surveys, as the Tertiary sediments can be mistaken for Recent alluvium. Area domestic well logs have been included as Appendix C to show the variability of Tertiary formations.

Recent alluvium covers most of the Tertiary sediments, as broad alluvial fans develop between the mountain uplands and the valley floor. The resulting deposits are a mixture of poorly sorted and non-uniform sand, gravels, and clays. The deposits have poor lateral continuity, often forming beds or lenses of lower permeability than that of the surrounding material (U.S.G.S., 1960).

On a regional scale, ground water is recharged in the uplands area, through precipitation and spring meltwater, and discharged in the valley area. Localized water table systems are often superimposed on the regional system, and generally discharge to surface water bodies.

Due to the high variability of the Recent deposits and the lateral discontinuity of the less permeable layers interspersed with more permeable materials, perched aquifers often form above the localized flow system. The impermeable layer causes vertically infiltrating ground water to collect atop the low-permeability material, creating a "false" water-table. Ground water moves laterally above the impermeable layer and ultimately discharges to the primary water-table aquifer or forms a seep, if the impermeable layer(s) intersect a slope. Perched water is often seasonally influenced and occurs only during periods of heavy precipitation. It is also possible to have multiply perched water systems lying above a primary water-table aquifer (U.S.G.S., 1960).

SITE HYDROGEOLOGY

Appendix D contains monitoring well and shop well logs for the Landfill. Comparison of the Landfill well logs with the area well logs shows the high variability and discontinuity of the Recent alluvial deposits (Appendix C).

The Landfill is characterized by higher permeability silts, sands and gravels interspersed with laterally discontinuous clay layers. As previously discussed, laterally discontinuous clay layers can cause perched aquifer systems to develop. Anomalous ground water elevations in M-1, and the occurrence of intermittent seeps along the western slope of the Landfill indicate perched conditions do exist at the Landfill (Figures 3 and 4, and Table 1).

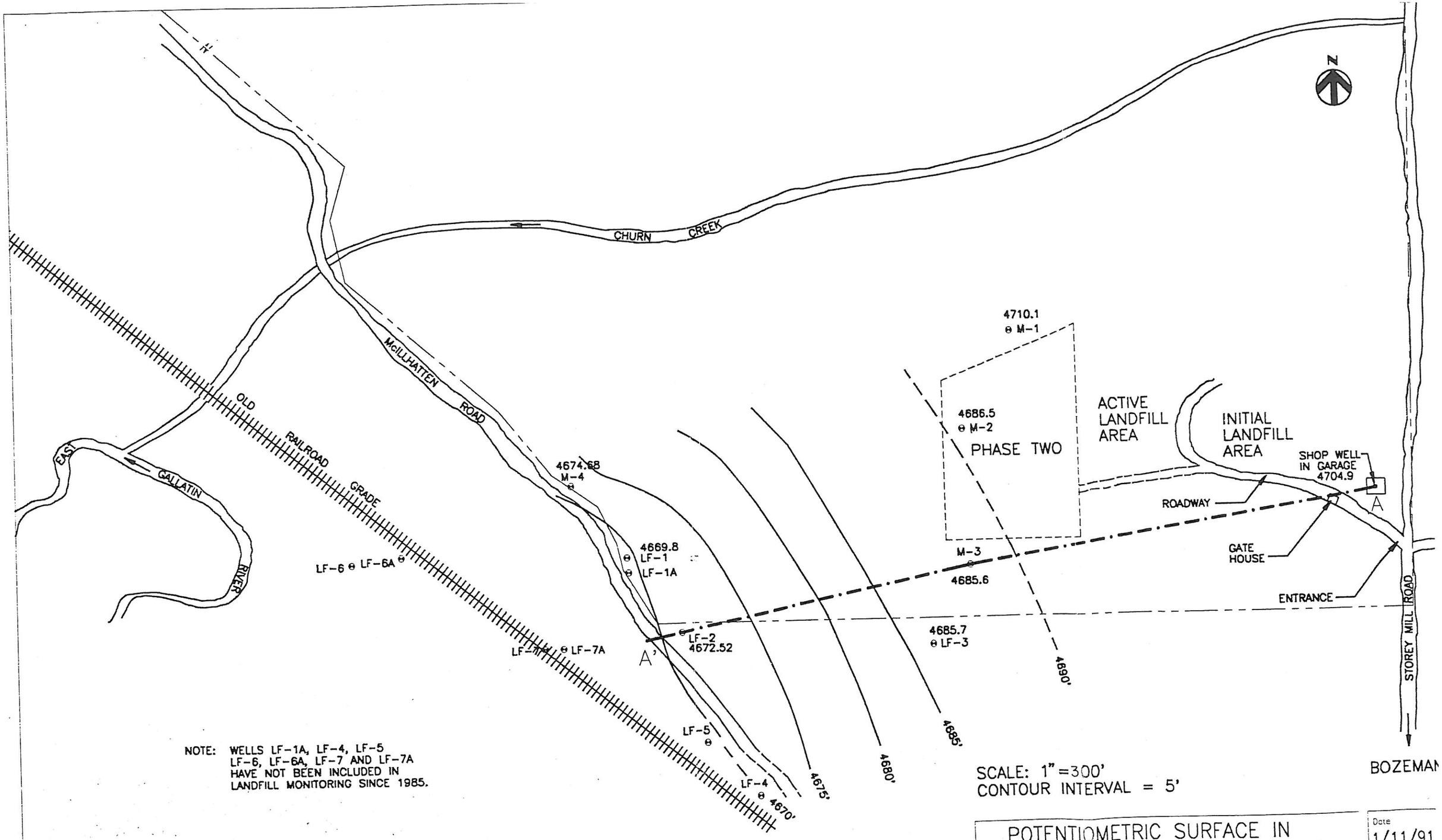
TABLE 1

STATIC WATER ELEVATIONS

JULY 1990

Well Identification	Elevation
M-1	4710.08
M-2	4686.52
M-3	4685.59
M-4	4674.68
LF-1	4669.79
LF-2	4672.52
LF-3	4685.67
SHOP	4704.90

Note: Shop static elevation taken in 1979, unable to access well head for static measurment.



NOTE: WELLS LF-1A, LF-4, LF-5 LF-6, LF-6A, LF-7 AND LF-7A HAVE NOT BEEN INCLUDED IN LANDFILL MONITORING SINCE 1985.

SCALE: 1"=300'
CONTOUR INTERVAL = 5'

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POTENTIOMETRIC SURFACE IN SHALLOW WATER TABLE AQUIFER BOZEMAN SANITARY LANDFILL BOZEMAN, MONTANA

Date: 1/11/91

Sheet: FIG.3

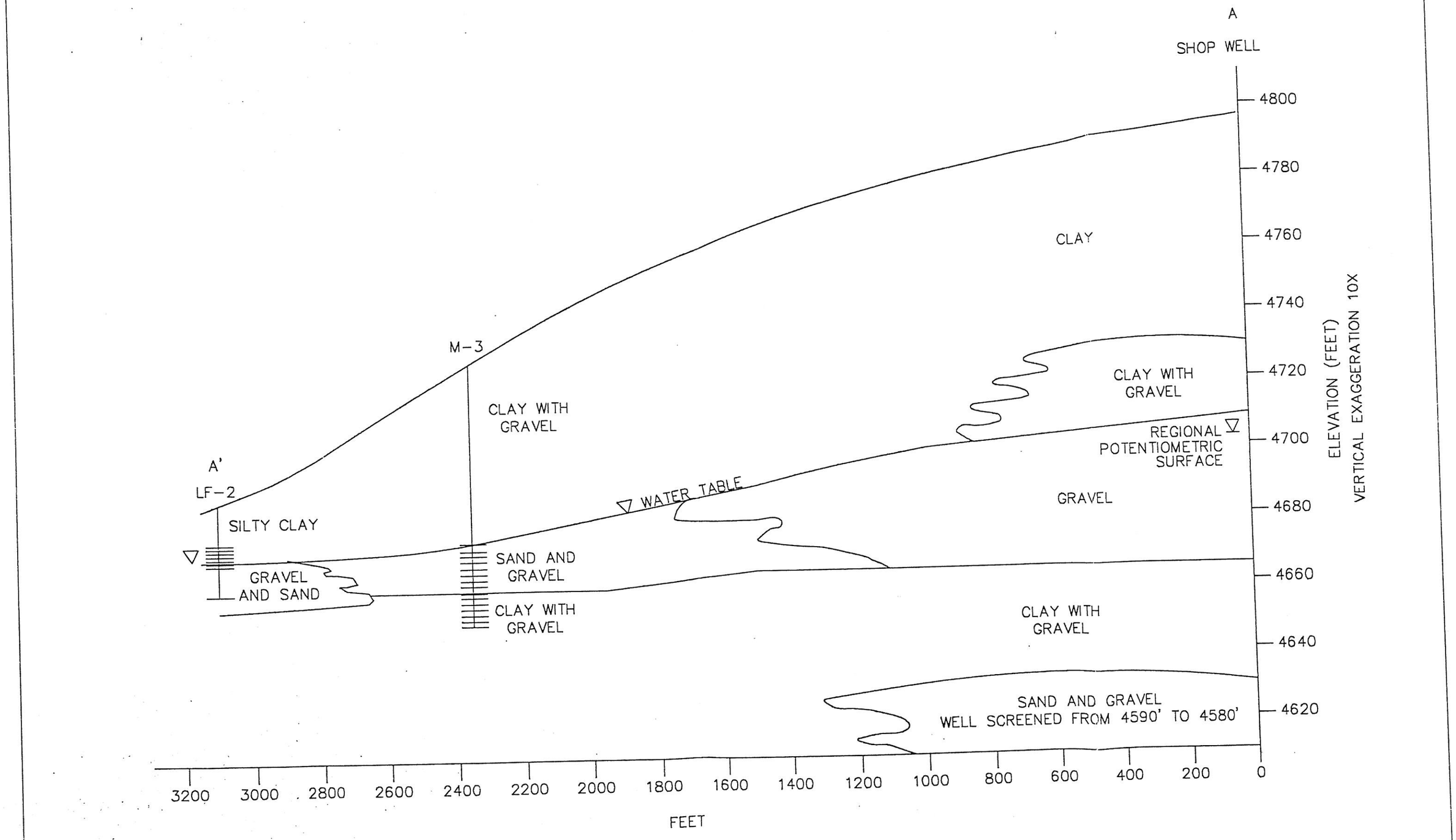

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FIGURE 4
CROSS-SECTION A'-A
(NOT TO SCALE)

Based upon cross-sections trending west to east across the Landfill and the potentiometric surface map, it appears there are possibly three aquifers; 1) one or more perched aquifer systems, 2) a water table or unconfined aquifer, and 3) the primary regional aquifer (Figures 3 and 4). Monitoring well M-1 is most likely screened in a perched aquifer(s), or its construction allows interconnection of a perched aquifer with the true shallow water table aquifer, thus influencing the pressure head in the well. The remaining monitoring wells are screened in the water table aquifer. The Shop well is screened in the deeper regional aquifer which is isolated from the water table aquifer by several clay layers (Appendix D). The lateral continuity of the clay layers and possible interconnection with the shallow water table aquifer is unknown, due to absence of additional wells terminated in the regional aquifer.

Ground water in the perched and water table aquifers flows westerly toward the East Gallatin River, where it discharges as baseflow, or as seeps in the case of perched aquifers (Figure 3). Average gradient across the water table aquifer is .016 ft/ft (Appendix G). The gradient has changed very little since 1985 when it was estimated to be .018 ft/ft from east to west across the Landfill (Stiller, 1985).

Ground water velocity is dependent upon the hydraulic conductivity of the material through which it flows. Since the aquifer materials are highly variable, ground water would flow more rapidly in more permeable deposits and be retarded in less permeable deposits. Assuming a maximum

hydraulic conductivity value of 150 feet/day for a coarse sand and a porosity of .39, average linear velocity is estimated at 6.15 feet/day. Assuming a minimum hydraulic conductivity of .00066 feet/day through clay and a porosity of .45, average linear velocity is 2.13×10^{-5} feet/day (Appendix G). These results are estimated based upon average table values assigned to physical characteristics described in the site well logs. Actual porosities and permeabilities may vary by one or more orders of magnitude (Driscoll, 1987 and Johnson, 1967).

Laboratory permeability testing conducted in 1987 on soil samples taken at M-4 indicated an average vertical permeability of 2.4×10^{-4} cm/sec or .68 feet/day. These results are suspect, as the tested sample was composited and disturbed during field collection, and recompacted prior to testing (Stiller, 1987).

The ground water flow direction in the regional aquifer cannot be determined due to the absence of other regional aquifer wells in the immediate area, but is assumed to be to the west, as well.

MONITORING WELL NETWORK EVALUATION

Construction and Design

During review of existing monitoring well boring logs, construction records, and visual inspection of the wells, several inadequacies were noted concerning design, construction and placement of the wells (Appendix D). These inadequacies may have affected prior ground water quality assessments performed at the Landfill.

The monitoring wells were installed during several different phases, therefore a variety of design and construction methods were utilized. As previously discussed, monitoring wells M-1, M-2 and M-3 were constructed in 1980 under the direction of the Soil Conservation Service (Stiller, 1985). M-2 collapsed in 1982 and was replaced with a second well adjacent to the original location. The replacement well was also labeled M-2. It is not known if the collapsed well was properly sealed or abandoned. Ten additional wells were installed by the Montana Bureau of Mines in 1985. The original monitoring well design plan of 1985 called for three, two-well nests and four individual wells. Each well nest would contain a deeper well and a shallow well screened in different water-bearing units. Drilling complications were encountered during the installation of the deeper wells, therefore each well nest was constructed with two wells screened at similar depths. M-4 was installed in 1986 and was the most recent monitoring well installed at the Landfill. Although the primary function of the shop well is for water supply, it is used as a "background" monitoring well. The shop well was installed in 1979 (Figure 2).

The lack of a proper annular seal between the well casing and the natural material is of primary concern with the current monitoring well construction. A properly placed annular seal is constructed of neat cement (Portland cement with less than 5 percent bentonite) with a "buffer" of bentonite between the neat cement and filterpack, to insure the neat cement does not intrude into the filterpack and well screen.

When the annular seal is omitted during well construction or is improperly placed several conditions may result relative to ground water quality, inaccurate water level measurements, and sample integrity. Cement can intrude into the well screen and render the well useless for monitoring well purposes due to; 1) screen blockage, and 2) extremely high pH (>11) measurements attributable to the CaOH in the cement. Based upon historical pH measurements taken at the monitoring wells, cement intrusion did not occur during construction. A conduit for contaminated surface water runoff to the ground water is often created. This is of particular concern at the Landfill, as the runoff generated in the vicinity of the Landfill is primarily from agricultural land. Nitrates and pesticides are the primary chemical constituents of agricultural runoff, therefore ground water sampling results would be subject to speculation relative to the origin of such contaminants. In addition, an improperly sealed well would encourage other contaminant transport from the ground surface to an underlying aquifer.

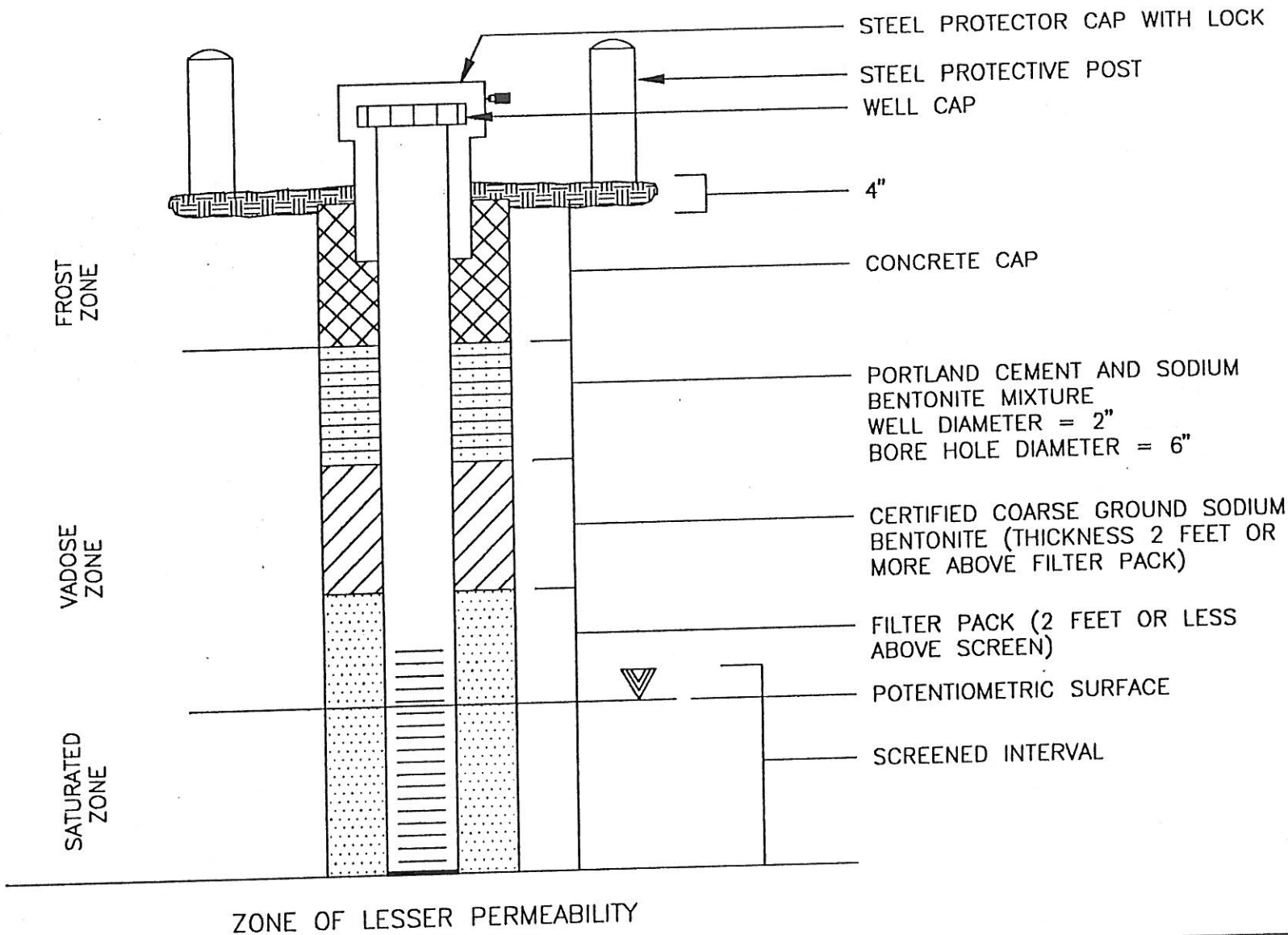
Migration of contaminants from the surface to the ground water is not the only method of contaminant transport caused by a poor or absent annular seal. Migration of contaminants from an overlying contaminated aquifer to a previously uncontaminated aquifer is also possible.

A standard monitoring well construction method has been established in the environmental industry and adopted by U.S. EPA in programs requiring ground water quality monitoring. Figure 5 provides details of a typical monitoring well with an annular seal (neat cement grout and bentonite) and other construction details.

In addition to annular seal problems, many of the wells contain materials that may interfere with sample quality and create difficulties in identifying contaminants associated with the Landfill. Several of the wells were constructed with bell and spigot joints glued together, rather than flush threaded joints. Adhesives and primers used in well construction generally contain organic compounds which could be detected in a total organic halogen analysis (TOX). TOX is a qualitative measurement of the presence haloganated molecules in a given sample, not a quantitative measurement of specific organic compounds. Since some of the wells have exhibited possible elevated TOX, the source of the halogens is of importance.

Formation packers were used to "seal" some of screened intervals in the wells. It is not known if the packers were composed of lead or neoprene. Anomalous detections of lead in the ground water may occur. Particularly, if the pH of the ground water is lowered and encourages leaching of lead from the packers. In addition, formation packers, regardless of their material, do not provide an effective barrier to annular migration for environmental monitoring purpose.

Several wells contain screens of lengths exceeding 10 feet or contain two screens. Generally, a 10 foot screen length is recommended to provide a discrete sampling interval. Cross migration of



EPA RECOMMENDED MONITOR WELL DESIGN

Date
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FIG.5

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contaminants from an upper aquifer to a lower aquifer is possible, if the screen intersects two different water bearing units. Cross contamination can also occur when two separate screens in the same well are used to draw from different aquifers.

Individual Monitoring Well Assessment

In addition to the monitoring wells currently used for ground water quality monitoring (Shop, M-1, M-2, M-3, M-4, LF-1, LF-2, and LF-3), there are other wells which are currently not included from the sampling schedule. These wells have been assessed individually with the active wells and their future usefulness for monitoring has been determined.

Monitoring wells M-1, M-2 and M-3 were constructed without the use of a neat cement grout and a bentonite seal. Packers were use to set the well screen thus, providing some protection against annular contaminant migration. However, as previously stated, the effectiveness of a formation packer as a barrier to annular contaminant migration is generally not sufficient for environmental monitoring purposes. In addition, these wells were constructed with glued joints and with one or more screens having a total length of twenty-five feet (Appendix D). Table 2 provides a summary of well construction and is recommended for future use.

M-2 is constructed with two screens of 10 and 12 feet in length, which appear to bridge two separate water-bearing zones (Table 2). M-2 is located in the expansion area and is subject to damage from heavy

TABLE 2 MONITORING WELL CONSTRUCTION SUMMARY

WELL NUMBER	CONSTRUCTION DETAILS	ABANDONMENT RECOMMENDATION
M-1	No annular seal, lead packer, glued joints, screen length 25 ft.	YES
M-2	No annular seal, lead packer, glued joints, two screens installed, located in expansion area.	YES
M-3	No annular seal, lead packer, glued joints, screen length 25 ft.	YES
M-4	Incomplete annular seal, glued joints.	YES
LF-1	No annular seal.	YES
LF-1A	No annular seal.	YES
LF-2	No surface seal.	YES
LF-3	No surface seal.	YES
LF-4	Annular seal present.	NO
LF-5	No annular seal.	YES
LF-6	No surface seal.	YES
LF-6A	No annular seal.	YES
LF-7	Discontinuous annular seal.	YES
LF-7A	Annular seal present.	NO
SHOP	Not designed for monitoring purposes, may not provide representative background sample.	NO

equipment. With the lack of annular seal there is the likelihood of contaminant migration to the substrate. Damage to the well head from Landfill activity could also lead to complications with contaminant migration (Appendix D).

Wells M-1 and M-3 should be considered for future abandonment, but may be maintained as monitoring points until such time the MDHES recommends removal based upon the absence of a properly placed surface seal. All analysis performed on M-1 and M-3 should include tetrahydrofuran (THF), methylethylketone (MEK), methlyisobutylketone (MIK) and cyclohexanone in addition to other proposed Subtitle D Phase I organic parameters. These compounds are the most common constituents of PVC primer and adhesives. Given the age of M-1 and M-3, the concentrations of these compounds may have diminished to negligible levels and the second or third rounds of Phase I sampling may indicate the adhesive and primer are negligible factors in terms of sample integrity. Consideration should be given to the packers as a possible source of lead, should future analysis indicate unusual levels of lead.

It is recommended that M-2 be properly abandoned with a tremied neat cement grout from the bottom of the well to the ground surface. An effort should be made to locate the old M-2 to assure it has been properly abandoned to eliminate a possible conduit for leachate or surface contaminant migration.

The next series of monitoring wells installed were LF-1, LF-1A, LF-2, LF-3, LF-4, LF-5, LF-6, LF-6A , LF-7 and LF-7A in 1985. Of these

ten wells only LF-1, LF-2 and LF-3 are currently utilized as ground water sampling points. Wells LF-1, LF-1A, LF-5 and LF-6A were installed without placement of any type of annular seal from the surface to the well screen. LF-7 has a surface seal from zero to 4 feet, but has filterpack from 4 to 8.5 feet before encountering a second bentonite seal. Therefore, the annular seal in LF-7 is considered to be discontinuous. Wells LF-2, LF-3 and LF-6 lack proper surface seals in the form of neat cement. Although, bentonite seals have been placed above the filterpack in these wells, offering some retardation to contaminant migration, the absence of an annular seal from the bentonite to the surface is a conduit to contaminant migration in these wells. Wells LF-4 and LF-7A have annular seals in the form of bentonite from the filterpack to the surface to provide a barrier to contaminant migration (Table 2).

In the absence of annular sealant, it is recommended that LF-1, LF-1A, LF-5 and LF-6A be abandoned in the same manner as M-2. Wells LF-2, LF-3, LF-6 and LF-7 have marginally acceptable construction relative to their surface seals, but most likely would be recommended for abandonment under Subtitle D. It is suggested that LF-2, LF-3, LF-6 and LF-7 remain as monitoring points at this time, but should be abandoned as soon as properly constructed monitoring wells can be installed. LF-4 and LF-7A have acceptable annular seals and should remain as possible monitoring points (Table 2).

Attempts to install annular seals is not suggested, as this requires overdrilling of the existing well casing which can result in

irreparable damage to the well, thus creating an unsealable conduit for contaminant migration, and is generally more costly than installing a new monitoring well.

Monitoring wells installed in 1985 were also constructed with adhesive and primer at the joints. Therefore, any subsequent sample analysis of ground water from these wells should include the THF, MEK, MIK and cyclohexanone.

Well M-4 was constructed with a bentonite seal from 1 to 2 feet, cuttings from 2 to 20.6 feet with a second bentonite seal from 20.6 to 23 feet. This is a similar construction to that utilized for LF-7. The adequacy of M-4 is marginal without a continuous annular seal. It is recommended that M-4 be utilized until such time it can be replaced with a properly constructed well. As adhesive and primer were used during construction, previously listed organic compounds should be included in future ground water analysis.

A minor construction feature which has been omitted from the monitoring wells is the use of three protective posts placed equidistant from the well head. Although the well heads have been secured with protective casing and padlocks with the exception of M-2), there is a risk of damage from heavy Landfill and agricultural equipment. We suggest protective posts be added to all monitoring wells which are not abandoned.

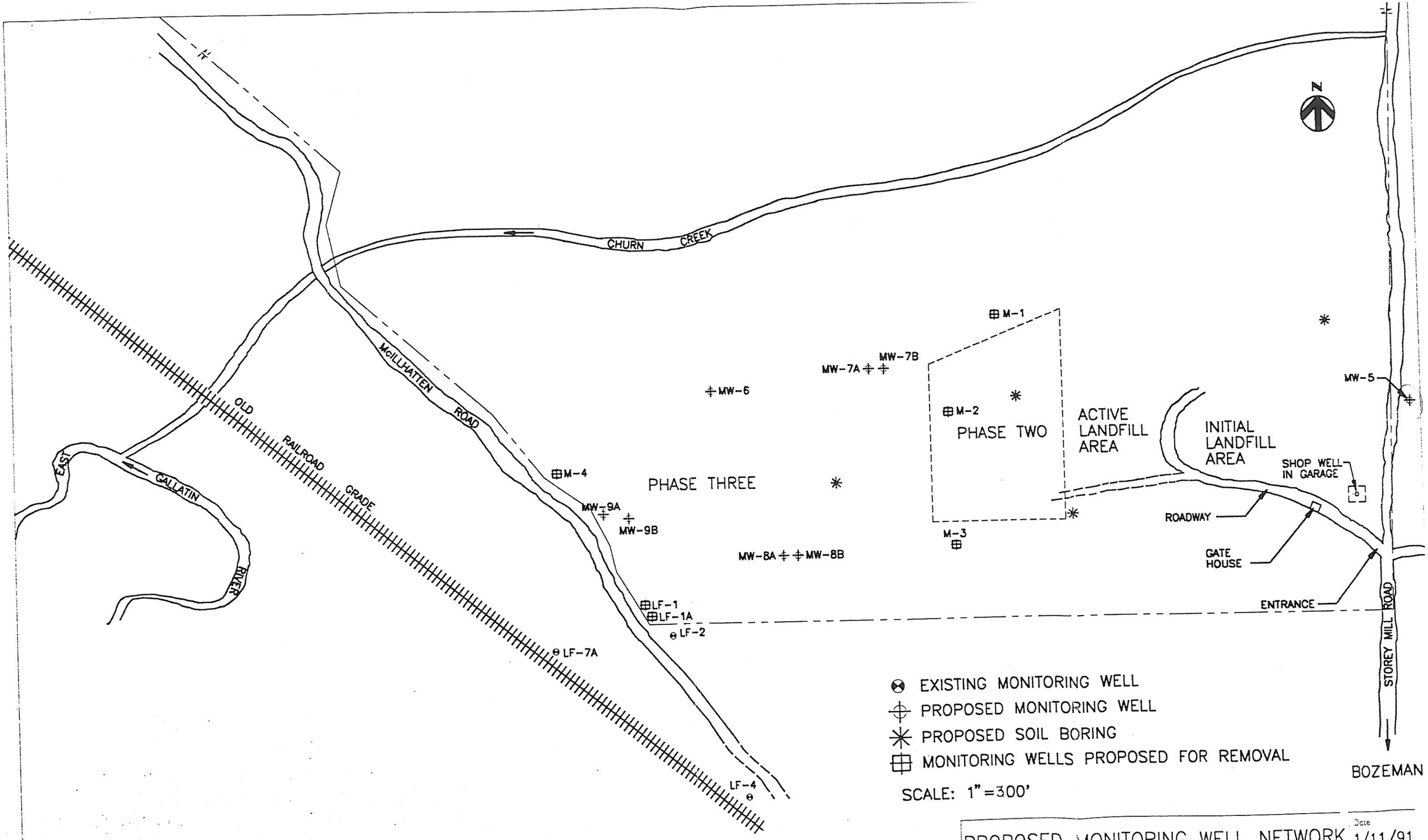
The Shop well was constructed for water supply purposes rather than ground water monitoring purposes. Monitoring wells are designed to sample a discrete interval of the aquifer of interest. Therefore, the Shop well's use as a background well for water quality purposes is limited primarily by its depth and screen placement in the deeper regional aquifer. In addition, submersible pumps tend to aerate well water, and therefore possibly interfere with accurate ground water sampling. To establish true background water quality, a monitoring well should be installed in the shallow water table aquifer, upgradient of the Landfill. Installation of monitoring wells through existing fill areas is not recommended, as this increases the risk of providing a contaminant conduit to the ground water during drilling activities.

All previously installed monitoring wells were constructed with four inch diameter PVC casing. In wells M-1, M-2 and M-3 heavy gauge Schedule 160 PVC casing was used. It is not necessary, for ground water monitoring purposes, to use materials of this diameter and weight. New monitoring wells can be constructed with 2 inch diameter flush joint and threaded Schedule 40 PVC casing. The cost of the monitoring wells can be significantly reduced with these lighter gauge materials. An added cost benefit is the reduced amount of grout and bentonite required for a smaller diameter borehole. To encourage optimum well development and provide less turbid water samples factory manufactured well screens of 10 or 20 slot sizes should be installed with a uniform number 30 filter pack (Figure 5).

Horizontal and Vertical Well Placement

Current horizontal monitoring well placement at the Landfill is adequate, with the exception of the northwestern margin and the background well. As previously indicated, the shop well, which draws water from the deeper regional aquifer, should be replaced with a monitoring well located further upgradient of the Landfill and terminated in the shallow water table aquifer. Although, the primary direction of ground water flow is to the west, toward the East Gallatin River, some flow is probable influenced by Churn Creek, when the creek is flowing. A monitoring well along the northwestern margin of the Landfill would fill this monitoring vacancy. As previously recommended, several monitoring wells should be abandoned. This will create monitoring gaps in the current well network, therefore new wells will be required. Figure 6 shows monitoring wells proposed for removal and their recommended replacements.

The vertical adequacy of the monitoring well network is more difficult to assess due to the local geology in the unconsolidated deposits. Current information concerning the occurrence of ground water in the area indicates ground water often exists under perched water conditions (Appendix D and Figures 3 and 4). This creates difficulties in locating the true water table during well installation. Nested wells are suggested to allow variability in permeabilities to be assessed, and to intercept any dense phase and light phase contaminants. The recommended replacement downgradient wells, as well as the upgradient background well should also be installed during the latter stages of a period of low precipitation to limit the possibility of intersecting perched aquifers.



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HDR Engineering, Inc.

PROPOSED MONITORING WELL NETWORK
BOZEMAN SANITARY LANDFILL
BOZEMAN, MONTANA

Date 1/11/91

Sheet FIG.6

SAMPLING METHODOLOGY AND ANALYTICAL INTERPRETATION

Overview

The extent of field activities for this hydrogeologic investigation involved ground water sampling of seven monitoring wells (M-1, M-2, M-3, M-4, LF-1, LF-2, LF-3) and the Shop well. The samples were analyzed for Phase I proposed Subtitle D inorganic parameters and physical parameters of pH, specific conductivity, and temperature. Since most of the monitoring wells have been recommended for removal and replacement in the future, and sampling results from current wells may be questionable, M-3 and M-4 were the only wells chosen for complete proposed Subtitle D Phase I listed volatile organic compound analysis (VOCs). The Phase I VOC list contains the most common organic compounds associated with solid waste facilities. M-3 and M-4 were also chosen, as these monitoring wells had historically shown the higher levels of chloride. A complete listing of the Phase I Subtitle D parameters that were analyzed for can be found in Appendix B. Seeps and surface water samples were not taken, as it was determined that agricultural and livestock runoff would probably influence the sampling validity. Domestic wells were not sampled, as historical data indicated that both the domestic wells and monitoring wells were within National Primary and Secondary Drinking Water Standards (Appendices B and F).

Quality Assurance/Quality Control Procedures

Quality assurance/quality control procedures were implemented to insure representative samples were taken. Each monitoring well was purged with a submersible pump. During the purging phase, temperature,

specific conductivity, and pH were monitored as an indicator of stabilization. After three consistent readings were obtained, the pump was withdrawn and each well was sampled with a stainless steel bailer. A stopcock was inserted into the bottom of the bailer to minimize disturbance of the sample while emptying the bailer. A decontaminated bailer and stopcock were used for each monitoring well to avoid cross contamination, i.e., no bailer was used more than one time for each well. The submersible pump was rinsed with distilled water between each well and a minimum of five gallons of water was drawn through the pump intake. The Shop well was sampled through the faucet after water was allowed to flow for 30 minutes. pH, specific conductivity, and temperature were also monitored to insure the well was stabilized prior to sampling.

Samples designated for metals analysis were filtered through a 45 micron Gelman disposable filter. A fresh filter was used for each monitoring well. Metal samples were preserved with 5 ml of HNO_3. Cyanide samples were preserved with 5 ml of NaOH. VOC samples were preserved with 2 ml of HCl. Care was exercised during VOC sample collection to avoid containerizing any air, by placing the bottle cap atop a positive miniscus. Fresh surgical gloves were used at each well during sampling. Sample containers were provided by Chen Northern, Inc. laboratory. All samples were packed in ice and vermiculite prior to direct shipment to Chen Northern Inc. located in Billings, Montana, via Greyhound Buslines. Due to the care exercised during field sampling to avoid cross contamination between wells, and a limited sampling budget, field, trip and/or bailer blanks were not taken. A duplicate sample was

taken at M-4 to assess laboratory QA/QC. Results for the duplicate sample correlate with the original sample taken at M-4 (Appendix B).

Results and Interpretations

Laboratory results for inorganic parameters, TOX, TOC and alkalinity indicate that overall ground water quality has not appreciably changed since the October 1989 sampling event (Appendix B). Comparison of the July 1990 chloride results to historical data indicates that, with the exception of the 1983 sampling results, chloride levels have remained fairly constant downgradient of the Landfill.

Chloride is generally considered to be a good leachate plume indicator parameter in non-saline ground water, as chloride ions; 1) are highly mobile in soils, including clays, because they are not affected by adsorption, 2) do not readily precipitate out of solution, 3) are not typical components of rock or soil, therefore residual chloride found in ground water is most often attributable to rainfall or connate water in older, regional aquifers, 4) generally occur at significant concentrations to be readily detectable, 5) do not undergo hydrolysis, thus yields a neutral pH in solution, e.g., NaCl, and 6) can be derived from chlorinated volatile organic compounds, which are sometimes contained in leachate (Drever, 1988).

Appendix E contains graphs representing chloride concentrations measured at the Landfill from 1981 through 1990. Table E-1 summarizes the chloride concentrations over this time period. To obtain greater

graphic resolution, monitoring wells M-1, M-2, M-4 , LF-1, LF-2, LF-3, and the Shop well were included on Figure E-1, while concentrations measured in M-3 and the Shop well were plotted on Figure E-2. The Shop well has been considered to represent background quality for the ground water at the Landfill for lack a more representative monitoring point. With the exception of the peak chloride levels that occurred during the May, June, and November 1983 sampling events, the chloride concentrations have remained fairly constant since sampling was initiated in 1981. The exception to these relative stable chloride levels is the anomalously high 1983 sample results.

Generally, as leachate is produced through natural degradation of solid waste, chloride concentrations tend to gradually increase with time. Results from the November 1982 and May 1983 sampling event indicate that chloride levels in M-3 went from less than .05 ppm to 450 ppm in approximately six months, and peaked at 624 ppm by July 1983. An increase in chloride levels was also reported in M-2 with the May 1983 sampling event, followed by a significant decrease July 1983, and another increase in November 1983 chloride levels before returning to pre-1983 levels. Fluctuations such as the one recorded in M-2 and M-3 are not typical of a leachate profile for solid waste faculties (Husain etal, 1989 and Robinson and Moris, 1979). The atypical chloride concentration profile, and the suspect sample collection and/or analysis methods employed in the 1983 sampling events, are considered to be reasonable justification to discount the 1983 results from the historical profile of the ground water quality downgradient of the Landfill.

Although, the 1983 sample results can most likely be considered as anomalous, the chloride levels in the downgradient wells have historical been ten to twenty times higher than those in Shop or background well. Again, this is assuming that the Shop well is extracting water from the same aquifer as the downgradient well. As previously discussed, the stratigraphic interpretation based upon the Landfill well logs suggests otherwise. If the Shop well is considered to represent background ground water quality, then a leachate plume of low concentration is most likely emanating from the landfill and has altered the ground water quality in the shallow water table aquifer.

VOC and TOX analysis performed on samples from M-3 and M-4, and TOX results for the remaining monitoring wells, further indicate that if a plume exists, it was low in concentration at the time of the July 1990 sampling. A limited comparison can be made between the TOX results which have been measured since the November 1988 sampling event and the VOC results of the July 1990 event.

TOX is a surrogate measurement used to estimated the total quantity of halogenated compounds in a given sample. TOX testing measures only the total molar amount of organically based halogens and does not provide information about the structure or nature of the organic compounds to which the halogens are bound, or information about the individual halogens present. The majority of the VOCs tested for in the July 1990 sampling round would be included in a TOX analysis. In effect, the TOX analysis represents a substantial part of total VOCs

detected in a given sample. It is possible to test for TOX and receive results above the method detection limit, yet test results for specific VOCs and related compounds indicate no individual organic compounds above the method detection limit. This is explained by the totality of TOX measurements. Individually, VOCs and related compounds may be occurring at levels below the method detection limit, but their summation of individual concentrations provides a sufficient quantity to be detected under the TOX analysis. This is most likely the explanation for the detection of TOX above the method detection limit in some of the downgradient monitoring wells, yet analysis for specific VOCs indicate VOCs are not present above the method detection limit (Appendix A). Another possible source for the TOX is well construction adhesives, as previously discussed, but in the absence of analytical data for the specific adhesive components, this is only speculative.

When TOX values for the downgradient wells are compared to those of the Shop well, the downgradient values are as much as six times higher than those measured for the Shop well in the same time period. Again, this is providing the Shop well is representative of background water quality. The elevated TOX results would indicate a limited plume is being produced by the landfill.

Due to the absence of a properly placed background well, it is difficult to assess overall impacts to ground water quality downgradient of the Landfill. Based upon chloride concentrations and TOX levels (discounting the TOX is from adhesives in the well), it does appear that a limited plume may have developed as a result of leachate generation

from the Landfill. However, when historical and recent sampling results, which are considered valid, are compared to current National Primary Drinking Water Standards, it can be shown that although the ground water captured downgradient of the Landfill has possibly been impacted, it has remained within the Standards (Appendix F).

CONCLUSIONS AND OBSERVATIONS

Based upon the historical data and information collected and reviewed, and the most recent ground water sampling results, the following conclusions and interpretations have been developed:

- Ground water exists under three different aquifer systems in the vicinity of the Landfill; 1) One or more perched aquifers, 2) a water table or unconfined aquifer, and 3) a regional aquifer.

- Aquifer permeability is highly variable based upon interpretation of well logs and estimated velocities.

- The extent of interconnection of the water table and regional aquifers is unknown.

- The majority of the monitoring wells located at the Landfill are improperly constructed, and therefore may possibly bias ground water sampling results and/or exacerbate any contaminant problems associated with the Landfill.

- The accuracy of the vertical permeability testing conducted on M-4 soil samples is highly suspect, as the sample was composited and disturbed upon collection, and recompacted prior to laboratory testing.

- The 1983 elevated chloride levels were most likely anomalous and biased through improper QA/QC procedure during sampling and analysis.

- Historical sample results from seeps can be considered questionable due to possible sample bias from agricultural and livestock runoff.

- Based upon historical and the most recently collected data, Primary Drinking Water Standards, which are health risk based, have not been exceeded in monitoring wells downgradient of the Landfill.

- VOC analysis of ground water sampled from M-3 and M-4 indicates that no Proposed Subtitle D Phase I organic parameters were found in these wells above laboratory method detection limits.

- Elevated chloride and TOX levels indicate a limited plume may have altered ground water quality downgradient, providing the Shop well is representative of ambient water conditions.

RECOMMENDATIONS

Based upon the aforementioned text and resulting conclusions, the following recommendations are made to improve ground water monitoring at the Landfill:

- It is recommended that monitoring wells M-2, LF-1, LF-1A, LF-5, and LF-6A be immediately sealed though proper abandonment due to lack of annular seals or other necessary construction features.

- Monitoring wells LF-2, LF-3, LF-6, LF-7, M-4, M-1, and M-3 should be abandoned in the near future, as their construction is marginally acceptable under industry and regulatory standards.

- Attempts to install annular seals on existing monitoring wells is not recommended due to risk of irreparable damage to the wells, and costs associated with repair versus overall abandonment and replacement with a new well.

- Monitoring wells LF-4 and LF-7A are properly constructed and should remain as part of the monitoring well network. However, analysis for common organic compounds contained in adhesives and primers should be included in any ground water analysis performed on these wells.

- The abandoned monitoring wells should be replaced with three, two-well nests to assess horizontal and vertical ground water flow and leachate migration. A single well should be placed along the northwestern margin to close the data gap created by the absence of a current monitoring point (Figure 7).

- The shop well should be removed from the monitoring schedule and replaced with a newly constructed background monitoring well, to provide a more representative profile of the shallow water table in the Landfill area.

- Additional soil borings, without the installation of monitoring wells, should also be considered to gain more detailed geologic and hydrologic profiles. Soil borings are of particular importance in future active areas where installation of wells is impractical and prohibited under proposed Subtitle D regulations. Four soil borings have been located on Figure 7 with the projected well locations.

- Laboratory permeability testing should be performed on select undisturbed shelby-tube soil samples taken during monitoring well and boring installation, to measure the vertical conductivity of the various unconsolidated material.

- Bail test should be performed on newly constructed well nests to determine horizontal conductivity of aquifer materials.

- To confirm or disprove regional aquifer interconnection with the water table aquifer, the Shop well should be used to conduct a pump test. If the pump cannot provide sufficient discharge, it can be temporarily replaced with one of increased horsepower. Care should be exercised during the pump test to route the discharge water away from the Landfill area, as induced recharge can negatively impact the test results. Newly installed monitoring wells can be used as observation wells to measure aquifer response.

- Ground water sampling for Phase I proposed Subtitle D inorganic parameters should continue on a maximum six month interval, unless otherwise required by MDHES for monitoring wells M-1, M-2, M-3, M-4 LF-1, LF-2, and LF-3, until the recommended replacement monitoring wells are installed.

- If Phase I inorganic constituents detected in the monitoring wells exceed the National Primary Drinking Water Standards or organic compounds are detected in the monitoring wells, the downgradient seeps and domestic wells should be placed on a biannual sampling schedule, unless otherwise specified by MDHES.

- All future sampling, with the recommended replacement monitoring wells, should include Phase I inorganic and organic parameters under the proposed Subtitle D legislation

to allow a database to be formed that will meet minimum regulatory requirements. The analysis should also include THF, MEK. MIK, and cyclohexanone if any current monitoring wells are used for sampling.

- QA/QC procedures similar to those used for the July 1990 sampling event should be used to insure sample integrity. A minimum of two blanks should be added to the sample analysis: 1) a trip blank of deionized water and 2) a field blank taken of rinsate from the submersible pump.

- After a minimum of two sampling events are conducted under the recommended monitoring well network and QA/QC procedures, the ground water quality downgradient can be assessed with more confidence than is available under current well conditions and past sampling protocol.

REFERENCES

Anderson et al., Hydrology and Geology of Montana State University Campus, March, 1982.

Bell, Scott, Morrison Maierle/CSSA, Bozeman, Montana, Personal Communications with Susan G. Price HDR Engineering, Inc,Minneapolis, Minnesota, November 30, 1990.

Bowen, D.W., Solid Waste Disposal Site Suitability Evaluation in Montana, M.S. Thesis, Montana State University, 1980.

Drevor, James, The Geochemistry of Natural Waters, 2nd edition, Prentice Hall, New Jersey, 1988.

Driscoll, Fletcher, Ground Water and Wells, 2nd edition, Johnson Division, St. Paul, Minnesota, 1987.

Griffith, E.E., Environmental Geology of the Southeast Margin of the Gallatin Valley, Gallatin County,Montana, M.S. Thesis, Montana State University, 1982.

Hughes, G.C., Cenezoic Geology and Geomorphology of the Dry Creek Valley, Gallatin County, Montana, M.S. Thesis, Montana State University, 1982.

Husain, T. et.al., Impact of Sanitary Landfill on Groundwater Quality, Water, Air, and Soil Pollution Vol 45, 1989.

Hydrometrics, Letter Report to Montana Department of Health and Environmental Sciences, Solid Waste Bureau, Helena, Montana, July 3, 1980.

Johnson, A,I., Specific Yield Compilation of Specific Yields for Various Materials, U.S.G.S. Water Supply Paper 1662-D, 1967.

Montana Geological Society, 1989 Field Guidebook, Montana Centennial Edition, 1989.

Northern Engineering and Testing, Inc., Technical Memorandum No.3, Engineering and Hydrogeological Evaluation of the Bozeman Sanitary Landfill, February, 1987.

Robinson, H.D., and Moris, P.J., Leachate from Domestic Waste Generation, Composition, and Treatment - A Review, U.K. Water Research Centre, March, 1979.

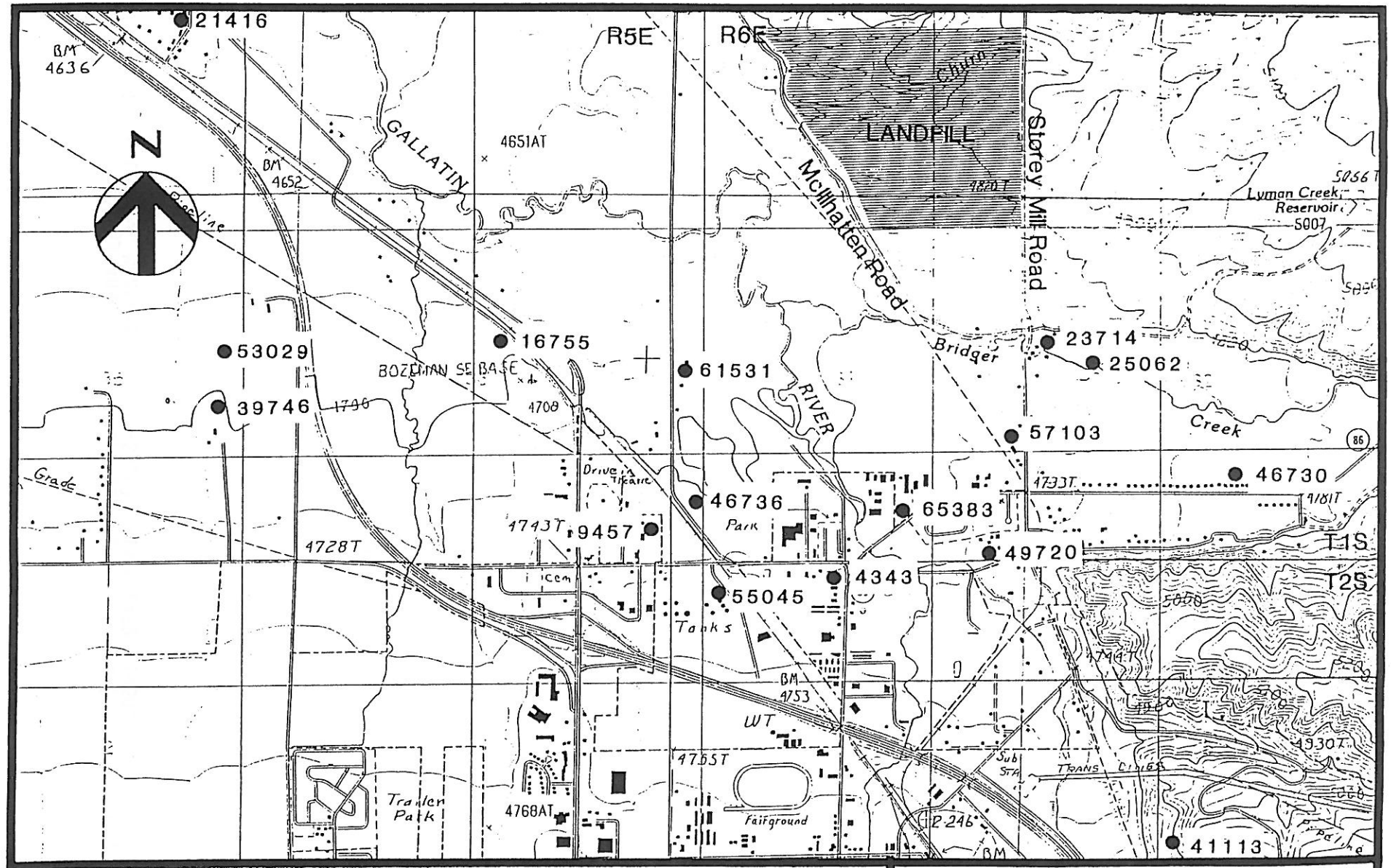
Stiller and Associates, Technical Memorandum No.1, Engineering and Hydrogeological Evaluation of the Bozeman Sanitary Landfill, December, 1985.

Stiller and Associates, Technical Memorandum No.2, Engineering and Hydrogeological Evaluation of the Bozeman Sanitary Landfill, July, 1986.

Soil Conservation Service, Bozeman Landfill Monitoring Plan, United States Department of Agriculture, Bozeman, Montana, 1981.

U.S.G.S., Bouguer Gravity, Aeromagnetic, and Generalized Geologic Map of the Eastern Part of the Three Forks Basin, Broadwater Madison, and Gallatin Counties, Montana, 1965.

U.S.G.S., Geology and Ground Water Resources of the Gallatin Valley, Gallatin County, Montana, Water-Supply Paper 1482, 1960.



HDR

HDR Engineering, Inc.

Morrison Maierle/CSSA INC.

Scale: 1"–2000'

Figure C-1
Area Well Locations
Bozeman Sanitary Landfill
Bozeman, Montana

APPENDIX A

GROUNDWATER ANALYSIS RESULTS

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: LF-1

DATE SAMPLED	10\17\85	5\08\86	8\11\87	12\03\87	5\26\88	11\14\88	5\15\89	
FIELD TESTS (Sampled by)	CITY BOZE	CITY BOZE	JS & SB	JS & SB	JS & SB	JS & SB	JS & SB	
PH	7.4	7.1	7.4	7.5	7.9	7.3	7.6	
SPECIFIC CONDUCTIVITY	527	491	655	640	670	590	625	
TEMPERATURE (degrees c)		7	10	9	15	12	12	
DISSOLVED OXYGEN (mg/l)			8.6	7.5	6.8	6.4	10	
STATIC H2O LEVEL (ft.)		14.7	15.9	16.6	16.1	16.9	16.7	
LABORATORY	MSU ANAL.	MSU LAB	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	MAX CONC LEVEL
Chloride as Cl, mg/l	2.1	2.1	18	17	18	17	19	250
Nitrate + Nitrite as N, mg/l	3.3	2.4	3	3.1	2.73	3.3	2.9	10
Sulfate as SO4, mg/l				12		23	13	250
Chemical Oxygen Demand, mg/l				6		27	<3	
Total Cyanide as CN, ug/l				<0.005			<0.005	
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l			<0.005	<0.005	<0.005	<0.005	<0.005	.05
Cadmium as Cd, ug/l			.006	38	<0.005	<0.005	<0.005	.1
Chromium as Cr, ug/l	.01		.02	<0.02	.02	.04	<0.02	.05
Iron as Fe	.11		.13	.65	.71	1.31	.17	.3
Lead as Pb	.02		<0.02	<0.02	<0.02	<0.02	<0.02	.05
Magnesium as Mg	24.8							
Manganese as Mn	.01		.04	.06	.08	.19	.05	.05
Nickel as Ni, ug/l	.01		<0.02	<0.02	<0.02	.03	<0.02	4
Zinc as Zn	.01		.02	.05	.02	.14	.06	
Calcium as Ca	75.2							
Sodium as Na								
Copper as Cu	.004							
Total Hg, ug/l								
Alkalinity as CaCO3								
Total Organic Carbon, mg/l	2	4.1	2	4.7	1.5	4.4	1.7	
Total Organic Halogens, ug/l								
Total Dissolved Solids	345							

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: LF-1

DATE SAMPLED	6\05\89	10\06\89	7\09\90					
FIELD TESTS (Sampled by)	RS & SM	RS & SM	SM & SP					
PH	7.3	7.1	7.3					
SPECIFIC CONDUCTIVITY	670	700	680					
TEMPERATURE (degrees c)	19	15	12					
DISSOLVED OXYGEN (mg/l)	8.3	8.6	10					
STATIC H20 LEVEL (ft.)	18.7	18.3	16					
LABORATORY	NORTH. ENG.	NORTH. ENG.	CHEN-NORTH.				MAX CONC LEVEL	
Chloride as Cl, mg/l	17	17	24					250
Nitrate + Nitrite as N, mg/l	2.68	2.82	3.2					10
Sulfate as S04, mg/l	19	13	13					250
Chemical Oxygen Demand, mg/l	32	<1	16					
Total Cyanide as CN, ug/l	<0.005	<0.005	<0.005					
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l	<0.005	<0.005	<0.005					.05
Cadmium as Cd, ug/l	<0.005	<0.005	<0.005					.1
Chromium as Cr, ug/l	<0.02	<0.02	<0.02					.05
Iron as Fe	.09	.11	1.99					.3
Lead as Pb	<0.02	<0.02	<0.01					.05
Magnesium as Mg								
Manganese as Mn	.05	.05	.16					.05
Nickel as Ni, ug/l	<0.02	.03	.03					4
Zinc as Zn	<0.02	.11						
Calcium as Ca			.07					
Sodium as Na								
Copper as Cu								
Total Hg, ug/l								
Alkalinity as CaC03								
Total Organic Carbon, mg/l	3.7	2.3	3.5					
Total Organic Halogens, ug/l			.025					
Total Dissolved Solids		7						

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: LF-2

DATE SAMPLED	10\16\85	5\8\86	8\11\87	12\03\87	5\26\88	11\14\88	5\15\89	
FIELD TESTS (Sampled by)	CITY BOZE	CITY BOZE	JS & SB	JS & SB	JS & SB	JS & SB	JS & SB	
PH	6.7	7.2	7.7	7.7	7.5	7.1	7.5	
SPECIFIC CONDUCTIVITY	490	486	610	610	615	580	580	
TEMPERATURE (degrees c)		7.5	10	9	15	10	8	
DISSOLVED OXYGEN (mg/l)			8.6	6.7	6.4	6.9	11.5	
STATIC H20 LEVEL (ft.)		14.2	15.5	16.2	15.4	15.7	15.7	
LABORATORY	MSU ANAL. LAB	MSU ANAL. LAB	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	MAX CONC LEVEL
Chloride as Cl, mg/l	25	27	23	20	23	20	23	250
Nitrate + Nitrite as N, mg/l	4.3	3.1	3.18	3.35	3.1	3.61	2.9	10
Sulfate as SO4, mg/l				16		23	15	250
Chemical Oxygen Demand, mg/l				<1		13	3	
Total Cyanide as CN, ug/l				<0.005			<0.005	
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l			<0.005	<0.005	<0.005	<0.005	<0.005	.05
Cadmium as Cd, ug/l			.009	<0.005	.006	<0.005	.006	.1
Chromium as Cr, ug/l	.01		.03	<0.02	<0.02	<0.02	<0.02	.05
Iron as Fe	.05		.98	.39	1.25	.46	.59	.3
Lead as Pb	.03		<0.02	<0.02	<0.02	<0.02	<0.02	.05
Magnesium as Mg	24.4							
Manganese as Mn	.01		.16	.05	.11	.04	.11	.05
Nickel as Ni, ug/l	.01		.02	<0.02	.02	<0.02	<0.02	
Zinc as Zn	.01		.21	.02	<0.02	<0.02	.08	
Calcium as Ca	74.3							
Sodium as Na								
Copper as Cu	.001							
Total Hg, ug/l								
Alkalinity as CaCO3								
Total Organic Carbon, mg/l	3	.7	2	1.4	2	1.6	2.6	
Total Organic Halogens, ug/l				9				
Total Dissolved Solids	351							

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: LF-2

DATE SAMPLED	6\05\89	10\06\89	7\09\90					
FIELD TESTS (Sampled by)	RS & SM	RS & SM	SM & SP					
PH	7.4	7.2	7.6					
SPECIFIC CONDUCTIVITY	610	610	630					
TEMPERATURE (degrees c)	15	9	11					
DISSOLVED OXYGEN (mg/l)	7.5	12.3	6.7					
STATIC H20 LEVEL (ft.)	15.4	16	15.5					
LABORATORY	NORTH. ENG.	NORTH. ENG.	CHEN-NORTH.					MAX CONC LEVEL
Chloride as Cl, mg/l	19	20	18					250
Nitrate + Nitrite as N, mg/l	3.5	3.3	3.42					10
Sulfate as SO4, mg/l	16	28	4					250
Chemical Oxygen Demand, mg/l	6	<1	12					
Total Cyanide as CN, ug/l	<0.005	<0.005	<0.005					
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l	<0.005	<0.005	<0.005					.05
Cadmium as Cd, ug/l	<0.005	<0.005	<0.005					.1
Chromium as Cr, ug/l	<0.02	<0.02	<0.02					.05
Iron as Fe	.06	.17	.08					.3
Lead as Pb	<0.02	<0.02	<0.01					.05
Magnesium as Mg								
Manganese as Mn	.04	.04	.05					.05
Nickel as Ni, ug/l	<0.02	<0.02	.03					
Zinc as Zn	<0.02	.05	.03					
Calcium as Ca								
Sodium as Na								
Copper as Cu								
Total Hg, ug/l								
Alkalinity as CaCO3								
Total Organic Carbon, mg/l	1.7	1.7	2.3					
Total Organic Halogens, ug/l	.01		.01					
Total Dissolved Solids								

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: LF-3

DATE SAMPLED	10\16\85	5\08\86	8\11\87	12\03\87	5\26\88	11\14\88	5\15\89	
FIELD TESTS (Sampled by)	CITY BOZE	CITY BOZE	JS & SB	JS & SB	JS & SB	JS & SB	RS & SM	
PH	6.5	7.3	6.8	7.9	7.5	7.2	7.6	
SPECIFIC CONDUCTIVITY	581	483	600	580	640	560	590	
TEMPERATURE (degrees c)		10	11	10	12.5	8	9	
DISSOLVED OXYGEN (mg/l)			7.8	7	6.4	9.4	10.2	
STATIC H20 LEVEL (ft.)		15.5	16.5	17.1	16.1	16.3	16.7	
LABORATORY	MSU ANAL. LAB	MSU ANAL. LAB	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	MAX CONC LEVEL
Chloride as Cl, mg/l	15	15	11	10	12	9	10	250
Nitrate + Nitrite as N, mg/l	.16	1.55	1.74	2.37	1.69	2.51	1.85	10
Sulfate as SO4, mg/l				7		7	8	250
Chemical Oxygen Demand, mg/l				<1		<2	<3	
Total Cyanide as CN, ug/l				<0.005			<0.005	
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l			<0.005	<0.005	<0.005	<0.005	<0.005	.05
Cadmium as Cd, ug/l			.008	<0.005	.005	<0.005	<0.005	.1
Chromium as Cr, ug/l	.004		.02	<0.02	<0.02	.04	<0.02	.05
Iron as Fe	.34		.68	.59	1.46	.54	.19	.3
Lead as Pb	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02	.05
Magnesium as Mg								
Manganese as Mn	<0.05		.07	.05	.09	.04	.06	.05
Nickel as Ni, ug/l			<0.02	<0.02	.03	<0.02	<0.02	
Zinc as Zn			<0.02	.03	<0.02	<0.02	.05	
Calcium as Ca	84.7							
Sodium as Na								
Copper as Cu	.01							
Total Hg, ug/l								
Alkalinity as CaCO3								
Total Organic Carbon, mg/l	2	<0.5	2	2.7	1.4	.8	1.5	
Total Organic Halogens, ug/l				8		11		
Total Dissolved Solids	372							

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: LF-3

DATE SAMPLED	6\05\89	10\06\89	7\09\90					
FIELD TESTS (Sampled by)	RS & SM	RS & SM	RS & SP					
PH	7.5	7.3	7.2					
SPECIFIC CONDUCTIVITY	640	610	630					
TEMPERATURE (degrees c)	15	9	10					
DISSOLVED OXYGEN (mg/l)	7.9	9.9	8.4					
STATIC H2O LEVEL (ft.)	16.3	16.6	16.5					
LABORATORY	NORTH. ENG.	NORTH. ENG.	CHEN-NORTH.					MAX CONC LEVEL
Chloride as Cl, mg/l	8	8	8					250
Nitrate + Nitrite as N, mg/l	1.97	1.92	2.46					10
Sulfate as SO4, mg/l	15	6	4					250
Chemical Oxygen Demand, mg/l	2	<1	12					
Total Cyanide as CN, ug/l	.005	<0.005	<0.005					
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l	<0.005	<0.005	<0.005					.05
Cadmium as Cd, ug/l	<0.005	<0.005	<0.005					.1
Chromium as Cr, ug/l	<0.02	<0.02	<0.02					.05
Iron as Fe	.1	.17	.75					.3
Lead as Pb	<0.02	<0.02	<0.01					.05
Magnesium as Mg								
Manganese as Mn	.05	.05	.07					.05
Nickel as Ni, ug/l	.02	<0.02	.05					
Zinc as Zn	<0.02	.03	.05					
Calcium as Ca								
Sodium as Na								
Copper as Cu								
Total Hg, ug/l								
Alkalinity as CaCO3								
Total Organic Carbon, mg/l	1.6	1.1	2.5					
Total Organic Halogens, ug/l		8	.014					
Total Dissolved Solids								

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN — DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL — PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-1

DATE SAMPLED	7\18\81	5\18\82	9\21\82	5\31\83	6\30\83	11\2\83	5\30\84	
FIELD TESTS (Sampled by)	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	
PH	7.5	7.7	8.3	7.3	7.2	7.5	7.6	
SPECIFIC CONDUCTIVITY	266	345	429	425	500	450	180	
TEMPERATURE (degrees c)								
DISSOLVED OXYGEN (mg/l)								
STATIC H2O LEVEL (ft.)		43	41	45			44	
LABORATORY	MSU	MSU ANAL. LAB	MSU ANAL. LAB	CITY LAB	CITY LAB	CITY LAB	CITY LAB	MAX CONC LEVEL
Chloride as Cl, mg/l	2.9	50.7	12.7	5	6.8	18	1	250
Nitrate + Nitrite as N, mg/l	2.7	2.8	3.8					10
Sulfate as SO4, mg/l	4.7	8						250
Chemical Oxygen Demand, mg/l	2.4	1.2	53.9		1	3.2	1.6	
Total Cyanide as CN, ug/l	<40	<40						
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l	1	1						.05
Cadmium as Cd, ug/l	1	1						.1
Chromium as Cr, ug/l	30	18	13	37.2	24.2	30.1	ND	.05
Iron as Fe	.03	.03						.3
Lead as Pb								.05
Magnesium as Mg	17.3	9						
Manganese as Mn	.01	.01						.05
Nickel as Ni, ug/l	1	1	1					
Zinc as Zn	.05	.05						
Calcium as Ca	47.2	57.5						
Sodium as Na	5.3	5.5						
Copper as Cu	.2	.2						
Total Hg, ug/l	.02	.02						
Alkalinity as CaCO3	184.2	184	175.7					
Total Organic Carbon, mg/l								
Total Organic Halogens, ug/l								
Total Dissolved Solids	226	308	242	240	264	280	248	

COMMENTS:
STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING
SAMPLING METHOD WAS WITH A PORTABLE PUMP
* The sample bottles broke during shipment
** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-1

DATE SAMPLED	11\21\84	5\17\85	5\08\86	8\11\87	12\3\87	5\26\88	11\14\88	
FIELD TESTS (Sampled by)	CITY BOZE	CITY BOZE	CITY BOZE	JS & SB	JS & SB	JS & SB	JS & SB	
PH	7.6	7.6	7.5	7.25	7.9	7.8	6.9	
SPECIFIC CONDUCTIVITY	390	390	310	430	405	430	390	
TEMPERATURE (degrees c)			9	10	8	10	8	
DISSOLVED OXYGEN (mg/l)				8.2	8	6.8	6.6	
STATIC H20 LEVEL (ft.)	52		43.6	44	45.8	45.3	45.6	
LABORATORY	MSU ANAL.	MSU LAB	MSU ANAL.	MSU LAB	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	MAX CONC LEVEL
Chloride as Cl, mg/l	2.4	6.3	5	2	1	3	2	250
Nitrate + Nitrite as N, mg/l			2.32	3.54	4	3.09	3.74	10
Sulfate as SO4, mg/l					9		9	250
Chemical Oxygen Demand, mg/l	ND	10			<1		<2	
Total Cyanide as CN, ug/l					<0.005			
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l				<0.005	<0.005	<0.005	<0.005	.05
Cadmium as Cd, ug/l			<0.01	<0.005	<0.005	.006	<0.005	.1
Chromium as Cr, ug/l	ND		.002	<0.02	<0.02	<0.02	<0.02	.05
Iron as Fe			<0.02	.16	.49	.11	.74	.3
Lead as Pb			<0.03	<0.02	<0.02	<0.02	<0.02	.05
Magnesium as Mg			<0.01					
Manganese as Mn			17	.02	.03	.03	.05	.05
Nickel as Ni, ug/l			<0.02	<0.02	<0.02	<0.02	<0.02	
Zinc as Zn			<0.03	<0.02	<0.02	<0.02	<0.02	
Calcium as Ca			<0.01					
Sodium as Na			49					
Copper as Cu			4					
			<0.01					
Total Hg, ug/l								
Alkalinity as CaCO3								
Total Organic Carbon, mg/l			<0.5	1.6	8	1	.6	
Total Organic Halogens, ug/l							8	
Total Dissolved Solids	210	220		240	264	280	210	

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-1

DATE SAMPLED	5\15\89	6\05\89	10\06\89	7\09\90				
FIELD TESTS (Sampled by)	RS & SM	RS & SM	RS & SM	SM & SP				
PH	7.2	6.3	6.8	7.7				
SPECIFIC CONDUCTIVITY	410	420	430	440				
TEMPERATURE (degrees c)	9	13	9	9				
DISSOLVED OXYGEN (mg/l)	9	7	7.4	10				
STATIC H20 LEVEL (ft.)	45.7	44.8	44.6	44.7				
LABORATORY	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	CHEN-NORTH.				MAX CONC LEVEL
Chloride as Cl, mg/l	4	<1	2	6				250
Nitrate + Nitrite as N, mg/l	3.4	3.91	3.75	4.26				10
Sulfate as SO4, mg/l	12	14	15	9				250
Chemical Oxygen Demand, mg/l	<3	2	<1	12				
Total Cyanide as CN, ug/l	<0.005	<0.005	<0.005	<0.005				
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l	<0.005	<0.005	<0.005	<0.005				.05
Cadmium as Cd, ug/l	<0.005	<0.005	<0.005	<0.005				.1
Chromium as Cr, ug/l	<0.02	<0.02	<0.02	<0.02				.05
Iron as Fe	.34	.09	.34	.14				.3
Lead as Pb	<0.02	<0.02	<0.02	<0.01				.05
Magnesium as Mg								
Manganese as Mn	.05	.03	.4	.36				.05
Nickel as Ni, ug/l	<0.02	<0.02	<0.02	.03				
Zinc as Zn	<0.02	<0.02	.03	.05				
Calcium as Ca								
Sodium as Na								
Copper as Cu								
Total Hg, ug/l								
Alkalinity as CaCO3								
Total Organic Carbon, mg/l	.9	.8	.9	1.3				
Total Organic Halogens, mg/l	.008			.008				
Total Dissolved Solids								

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-2

DATE SAMPLED	5\18\82	9\21\82	5\31\83	6\30\83	11\02\83	5\30\84	11\21\84	
FIELD TESTS (Sampled by)	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	
PH	7.1	7.7	6.5	6.6	6.7	6.9	6.9	
SPECIFIC CONDUCTIVITY	906	1040	990	1270	1080	970	970	
TEMPERATURE (degrees c)								
DISSOLVED OXYGEN (mg/l)								
STATIC H20 LEVEL (ft.)	56	54	56				58	
LABORATORY	MSU ANAL.	MSU LAB	CITY ANAL.	CITY LAB	CITY LAB	CITY LAB	MSU ANAL.	MSU LAB	MAX CONC LEVEL
Chloride as Cl, mg/l	33.8	20.5	65	11.5	68	17	17	250
Nitrate + Nitrite as N, mg/l	1.38	2.45						10
Sulfate as SO4, mg/l	1.6							250
Chemical Oxygen Demand, mg/l	2.1	21.2		1	12.8	33	33	
Total Cyanide as CN, ug/l	40							
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l	1							.05
Cadmium as Cd, ug/l	1							.1
Chromium as Cr, ug/l	60	10	142	30.5	78.1	ND	ND	.05
Iron as Fe	.1							.3
Lead as Pb								.05
Magnesium as Mg	50							
Manganese as Mn								.05
Nickel as Ni, ug/l	1.5	1	1					
Zinc as Zn	.05							
Calcium as Ca	185							
Sodium as Na	12							
Copper as Cu	.02							
Total Hg, ug/l	.02							
Alkalinity as CaCO3	597	495.4	495.4					
Total Organic Carbon, mg/l								
Total Organic Halogens, ug/l								
Total Dissolved Solids	721	643	576	656	584	540	540	

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-2

DATE SAMPLED	5\17\85	10\15\85	5\8\86	8\11\87	12\03\87	5\26\88	11\14\88	
FIELD TESTS (Sampled by)	CITY BOZE	CITY BOZE	CITY BOZE	JS & SB	JS & SB	JS & SB	JS & SB	
PH	7.1	6.5	7.4	7.5	7.4	7.4	6.8	
SPECIFIC CONDUCTIVITY	1000	566	356	675	620	550	460	
TEMPERATURE (degrees c)			10	11	8	11.5	9	
DISSOLVED OXYGEN (mg/l)				7	6	7	6.1	
STATIC H20 LEVEL (ft.)			55.8	58.5	58.5	58.2	58.1	
LABORATORY	MSU ANAL.	MSU LAB	MSU ANAL.	MSU LAB	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	MAX CONC LEVEL
Chloride as Cl, mg/l	29	14	7	10	9	6	6	250
Nitrate + Nitrite as N, mg/l		1.89	3.6	2.76	3.27	2.87	4.8	10
Sulfate as SO4, mg/l					8		10	250
Chemical Oxygen Demand, mg/l	10	2			<1		6	
Total Cyanide as CN, ug/l					<0.005			
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l			<0.1	.005	<0.005	<0.005	<0.005	.05
Cadmium as Cd, ug/l			.002	.007	<0.005	.01	<0.005	.1
Chromium as Cr, ug/l		.004	<0.02	<0.02	<0.02	.05	<0.02	.05
Iron as Fe		.03	<0.03	.48	.32	4.99	.6	.3
Lead as Pb			<0.01	<0.02	<0.02	<0.02	<0.02	.05
Magnesium as Mg		29.1	17					
Manganese as Mn		.04	<0.02	.57	.27	.41	.08	.05
Nickel as Ni, ug/l		.42	<0.03	<0.02	<0.02	.03	<0.02	
Zinc as Zn		.002	<0.01	<0.02	<0.02	.05	<0.02	
Calcium as Ca		.02	55					
Sodium as Na		98.5	4					
Copper as Cu		.001	<0.01					
Total Hg, ug/l								
Alkalinity as CaCO3								
Total Organic Carbon, mg/l		2		2	29	1.4	.8	
Total Organic Halogens, ug/l					9			
Total Dissolved Solids	630	377						

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN
DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL
PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-2

DATE SAMPLED	5\15\89	6\05\89	10\06\89	7\10\90				
FIELD TESTS (Sampled by)	RS & SM	RS & SM	RS & SM	SM & AP				
PH	6.6	6.1	6.9	7.6				
SPECIFIC CONDUCTIVITY	450	520	510	670				
TEMPERATURE (degrees c)	11	15	12	10				
DISSOLVED OXYGEN (mg/l)	6.9	7	6.4	7.1				
STATIC H20 LEVEL (ft.)	58.7	58.4	***48.1	***48.0				
LABORATORY	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	CHEN-NORTH.				MAX CONC LEVEL
Chloride as Cl, mg/l	6	4	6	16				250
Nitrate + Nitrite as N, mg/l	3.7	2.68	3.63	3.14				10
Sulfate as SO4, mg/l	14	20	8	7				250
Chemical Oxygen Demand, mg/l	<3	2	<1	10				
Total Cyanide as CN, ug/l	<0.005	<0.005	<0.005	<0.005				
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l	<0.005	<0.005	<0.005	<0.005				.05
Cadmium as Cd, ug/l	<0.005	<0.005	<0.005	<0.005				.1
Chromium as Cr, ug/l	<0.002	<0.02	<0.02	<0.02				.05
Iron as Fe	.55	.1	.26	.34				.3
Lead as Pb	<0.02	<0.02	<0.02	<0.01				.05
Magnesium as Mg			17					
Manganese as Mn	.08	.18	.13	.2				.05
Nickel as Ni, ug/l	<0.02	<0.02	<0.02	.02				
Zinc as Zn	<0.02	<0.02	.04	<0.02				
Calcium as Ca								
Sodium as Na								
Copper as Cu								
Total Hg, ug/l								
Alkalinity as CaCO3								
Total Organic Carbon, mg/l	1.1	1	1.2	1.3				
Total Organic Halogens, ug/l			<5	.031				
Total Dissolved Solids	630	377						

COMMENTS:
STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING
SAMPLING METHOD WAS WITH A PORTABLE PUMP
* The sample bottles broke during shipment
** To be reported upon completion
***Well cap cut off since last recording

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: November 15, 1989

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-3

DATE SAMPLED	11\18\81	5\18\82	10\21\82	5\31\83	6\30\83	10\04\83	7\30\84	
FIELD TESTS (Sampled by)	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	
PH	7.5	7.7	7.9	7	6.8	7	7.05	
SPECIFIC CONDUCTIVITY	238	821	1170	1050	1390	1500	860	
TEMPERATURE (degrees c)								
DISSOLVED OXYGEN (mg/l)								
STATIC H20 LEVEL (ft.)								
DEPT. HEALTH & ENVIR SCI WATER BUREAU, CHEM LAB	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	MAX CONC LEVEL
Chloride as Cl, mg/l	6.8	7.2	<0.05	450	624		45.9	250
Nitrate + Nitrite as N, mg/l	.45	.53	.37					10
Sulfate as SO4, mg/l	1.3	2.6						250
Chemical Oxygen Demand, mg/l	103.6	25.2	31	25.8	5.2	19.6	13	
Total Cyanide as CN, ug/l	40	<40						
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l	.01	<1						.05
Cadmium as Cd, ug/l	.01	<1						.1
Chromium as Cr, ug/l	.02	.06	3		25.3			.05
Iron as Fe	.03	<0.03						.3
Lead as Pb								.05
Magnesium as Mg	17.5							
Manganese as Mn	.01	.01						.05
Nickel as Ni, ug/l	1	4.8	<1					
Zinc as Zn	.18	<0.05						
Calcium as Ca	39.9	45						
Sodium as Na	8	7.9						
Copper as Cu	.02	<0.02						
Total Hg, ug/l	.02	<0.02						
Alkalinity as CaCO3	182.4	178	228.5					
Total Organic Carbon, mg/l								
Total Organic Halogens, ug/l								
Total Dissolved Solids	194	218	315	724	792	773	788	

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: November 15, 1989

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-3

DATE SAMPLED	11\21\84	5\17\85	11\11\85	5\08\86	8\11\87	12\03\87	5\26\88	
FIELD TESTS (Sampled by)	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	
PH	7.1	6.8	6.5	6.9	7	7.2	7.5	
SPECIFIC CONDUCTIVITY	1200	1100	1250	896	1100	1000	990	
TEMPERATURE (degrees c)				8	8	9	9.5	
DISSOLVED OXYGEN (mg/l)					7.6	7.3	6.9	
STATIC H2O LEVEL (ft.)			49.3	49.8	50.6	51	51.7	
DEPT. HEALTH & ENVIR SCI WATER BUREAU, CHEM LAB	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	MAX CONC LEVEL
Chloride as Cl, mg/l	40	54	53	42	30	28	26	250
Nitrate + Nitrite as N, mg/l			2.9	2.34	2.7	1.92	1.76	10
Sulfate as SO4, mg/l						18		250
Chemical Oxygen Demand, mg/l	29	16	9			<1		
Total Cyanide as CN, ug/l						<0.005		
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l				<0.01	<0.005	<0.005	<0.005	.05
Cadmium as Cd, ug/l				.002	.008	<0.005	<0.005	.1
Chromium as Cr, ug/l	ND	ND		<0.02	<0.02	<0.02	<0.02	.05
Iron as Fe				<0.03	.22	.09	.1	.3
Lead as Pb				<0.01	.03	<0.02	<0.02	.05
Magnesium as Mg								
Manganese as Mn				<0.02	.07	.05	.06	.05
Nickel as Ni, ug/l				<0.03	.03	<0.02	.03	
Zinc as Zn				<0.01	.17	.02	<0.02	
Calcium as Ca				145				
Sodium as Na				15				
Copper as Cu				<0.01				
Total Hg, ug/l								
Alkalinity as CaCO3								
Total Organic Carbon, mg/l			3	6.8	2.6	3.6	2.3	
Total Organic Halogens, ug/l								
Total Dissolved Solids	720	730						

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: November 15, 1989

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-3

DATE SAMPLED	11\14\88	5\15\89	6\05\89	10\06\89	7\09\90			
FIELD TESTS (Sampled by)	JS & SB	RS & SM	RS & SM	RS & SM	SM & SP			
PH	6.7	6.3	7.4	7	7.5			
SPECIFIC CONDUCTIVITY	950	950	850	970	1020			
TEMPERATURE (degrees c)	8.5	10	14	10	9			
DISSOLVED OXYGEN (mg/l)	6.6	7.6	7	7.4	7.6			
STATIC H2O LEVEL (ft.)	51.9	51.7	51	51.1	50.9			
DEPT. HEALTH & ENVIR SCI WATER BUREAU, CHEM LAB	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	CHEN- NORTH.			MAX CONC LEVEL
Chloride as Cl, mg/l	28	23	17	24	23			250
Nitrate + Nitrite as N, mg/l	2.1	1.85	1.97	1.92	2.02			10
Sulfate as SO4, mg/l	6	19	12	12	9			250
Chemical Oxygen Demand, mg/l	19	<3	8	<1	14			
Total Cyanide as CN, ug/l		<0.005	<0.005	<0.005	<0.005			
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l	<0.005	<0.005	<0.005	<0.005	<0.005			.05
Cadmium as Cd, ug/l	<0.005	<0.005	<0.005	<0.005	<0.005			.1
Chromium as Cr, ug/l	.04	<0.02	<0.02	<0.02	<0.02			.05
Iron as Fe	.84	.09	.08	.08	.08			.3
Lead as Pb	<0.02	<0.02	<0.02	<0.02	<0.01			.05
Magnesium as Mg					34			
Manganese as Mn	.09	.05	.05	.06	.06			.05
Nickel as Ni, ug/l	<0.02	<0.02	<0.02	<0.02				
Zinc as Zn	.03	.05	<0.02	.04				
Calcium as Ca					97			
Sodium as Na					12			
Copper as Cu								
Total Hg, ug/l					<0.02			
Alkalinity as CaCO3					365			
Total Organic Carbon, mg/l	2.6	2.1	2.1	2	2.8			
Total Organic Halogens, ug/l	43			27				
Total Dissolved Solids	720	730			452			

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-3

DATE SAMPLED					7\09\90			
FIELD TESTS (Sampled by)					SM & SP			
LABORATORY					CHEN-NORTH.			MAX CONC LEVEL
Ammonia Nitrogen as N, mg/l					<0.2			
Total Alkalinity as CaCO3, m					365			
Calcium as Ca, mg/l					97			
Potassium as K, mg/l					<1			
Sodium as Ns, mg/l					12			
Dissolved Beryllium as Be					.1			
Dissolve Mercury as Hg					<0.002			
Dissolved Selenium as Se					<0.005			
Dissolved Silver as Ag					<0.001			
Bromochlorometnane, ug/l					<5			
1,4 Difluorobenzene, ug/l					<5			
Ethanol, ug/l					<1000			
4 Bromofluorobenzene, ug/l					<5			
Carbon tetrachloride, ug/l					<5			
Vinyl Acetate, ug/l					<50			
Bromodichloromethane, ug/l					<5			
trans-1,3-Dichloropropene ug/l					<5			
					<5			
Trichloroethene, ug/l					<5			
1,1,2-Trichloroethane, ug/l					<5			
Benzene, ug/l					<5			
cis-1,3-Dichloropropene,ug/l					<5			
Bromoform, ug/l					<5			
trans-1,4-dichloro-2-butene					<100			
1,2,3-Trichloropropane, ug/l					<5			
2-Hexanone, ug/l					<50			
4-Methyl-2-Pentanone, ug/l					<50			
1,1,2,2-Tetrachloroethane					<5			
Toluene, ug/l					<5			
Ethyl methacrylate, ug/l					<5			
Chlorobenzene, ug/l					<5			
ethylbenzene, ug/l					<5			
Styrene,m ug/l					<5			
Xylenes (total), ug/l					<5			
2-Chloroethyl vinyl ether,mg					<10			

COMMENTS:

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-3

DATE SAMPLED					7\09\90			
FIELD TESTS (Sampled by)					SM & SP			
LABORATORY					CHEN-NORTH.			MAX CONC LEVEL
Chloromethane, ug/l					<10			
Bromoethane, ug/l					<10			
Vinyl Chloride, ug?l					<10			
Dichlorodifluoromethane					<5			
Chloroethane, ug/l					<10			
Methyl iodide, ug/l					<5			
Acrolein, mg/l					<100			
Acrylonitrile, ug/l					<100			
Methylene Chloride, ug/l					<5			
Acetone, ug/l					<100			
Trichlorofluoromethane, ug/l					<5			
Carbon Disulfide, ug/l					<100			
1,1-Dichloroethene, ug/l					<5			
Chloroform, ug/l					<5			
1,2-Dichloroethane, ug/l					<5			
2-Butanone, ug/l					<100			
Dibromomethane, ug/l					<5			
1,1,1-Trichloroethane, ug/l					<5			

COMMENTS:

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON-MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-4

DATE SAMPLED	5\8\86	8\11\87	12\3\87	5\26\88	11\14\88	5\15\89	6\05\89	
FIELD TESTS (Sampled by)	CITY BOZE	JS & SB	JS & SB	JS & SB	JS & SB	JS & SB	JS & SB	
PH	8	7.6	7.7	7.5	6.8	6.7	7.3	
SPECIFIC CONDUCTIVITY	814	945	875	900	805	870	860	
TEMPERATURE (degrees c)	8	10	8	11	9	13	20	
DISSOLVED OXYGEN (mg/l)		8.5	6.7	7	6.5	7.3	7	
STATIC H2O LEVEL (ft.)	20.6	22	22.3	22.1	22	22	22	
LABORATORY	ENERGY LABS	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	MAX CONC LEVEL
Chloride as Cl, mg/l	21	15	11	12	10	13	8	250
Nitrate + Nitrite as N, mg/l	2.46	1.8	2.75	1.48	2.22	1.9	1.97	10
Sulfate as SO4, mg/l			9		10	11	8	250
Chemical Oxygen Demand, mg/l			<1		11	<3	2	
Total Cyanide as CN, ug/l			<0.005			<0.005	<0.005	
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l	<0.1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	.05
Cadmium as Cd, ug/l	.003	.007	<0.005	.007	<0.005	<0.005	<0.005	.01
Chromium as Cr, ug/l	<0.02	.05	<0.02	<0.02	.03	<0.02	<0.02	.05
Iron as Fe	.03	2.9	.73	2.3	.42	.17	.18	.3
Lead as Pb	.01	.02	<0.02	<0.02	<0.02	.02	<0.02	.05
Magnesium as Mg	44							
Manganese as Mn	.29	.03	.07	.13	.04	.06	.06	.05
Nickel as Ni, ug/l	<0.03	.03	<0.02	.03	<0.02	.04	.02	
Zinc as Zn	<0.01	<0.02	.04	<0.02	<0.02	.06	.06	
Calcium as Ca	139							
Sodium as Na	14							
Copper as Cu	<0.01							
Total Hg, ug/l								
Alkalinity as CaCO3								
Total Organic Carbon, mg/l	1.7	1.7	1.9	1.6	1.2	2	1.6	
Total Organic Halogens, ug/l			21		22		23	
Total Dissolved Solids								

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-4

DATE SAMPLED	10\06\89	7\09\90						
FIELD TESTS (Sampled by)	RS & SM	SM & SP						
PH	7.1	7.2						
SPECIFIC CONDUCTIVITY	910	860						
TEMPERATURE (degrees c)	12	12						
DISSOLVED OXYGEN (mg/l)	7.2	7.1						
STATIC H2O LEVEL (ft.)	22.2	22.3						
LABORATORY	CHEN. NORTH.	CHEN. NORTH.						MAX CONC LEVEL
Chloride as Cl, mg/l	11	10						250
Nitrate + Nitrite as N, mg/l	1.92	2.02						10
Sulfate as SO4, mg/l	4	13						250
Chemical Oxygen Demand, mg/l	<1	4						
Total Cyanide as CN, ug/l	<0.005	<0.005						
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l	<0.005	<0.005						.05
Cadmium as Cd, ug/l	<0.005	<0.005						.01
Chromium as Cr, ug/l	<0.02	<0.02						.05
Iron as Fe	.18	.12						.3
Lead as Pb	<0.02	<0.01						.05
Magnesium as Mg								
Manganese as Mn	.06	.06						.05
Nickel as Ni, ug/l	.02							
Zinc as Zn	.06							
Calcium as Ca								
Sodium as Na								
Copper as Cu								
Total Hg, ug/l								
Alkalinity as CaCO3								
Total Organic Carbon, mg/l	1.6	1.7						
Total Organic Halogens, ug/l	23							
Total Dissolved Solids								

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-4

DATE SAMPLED	7\09\90					
FIELD TESTS (Sampled by)	SM & SP					
LABORATORY	CHEN-NORTH.					MAX CONC LEVEL
Ammonia Nitrogen as N, mg/l	<0.2					
Total Alkalinity as CaCO3, m	390					
Calcium as Ca, mg/l	100					
Potassium as K, mg/l	1					
Sodium as Ns, mg/l	12					
Dissolved Beryllium as Be	.01					
Dissolve Mercury as Hg	<0.002					
Dissolved Selenium as Se	<0.005					
Dissolved Silver as Ag	<0.001					
Bromochloromethane, ug/l	<5					
1,4 Difluorobenzene, ug/l	<5					
Ethanol, ug/l	<1000					
4 Bromofluorobenzene, ug/l	<5					
Carbon tetrachloride, ug/l	<5					
Vinyl Acetate, ug/l	<50					
Bromodichloromethane, ug/l	<5					
trans-1,3-Dichloropropene ug/l	<5					
	<5					
Trichloroethene, ug/l	<5					
1,1,2-Trichloroethane, ug/l	<5					
Benzene, ug/l	<5					
cis-1,3-Dichloropropene,ug/l	<5					
Bromoform, ug/l	<5					
trans-1,4-dichloro-2-butene	<100					
1,2,3-Trichloropropane, ug/l	<5					
2-Hexanone, ug/l	<50					
4-Methyl-2-Pentanone, ug/l	<50					
1,1,2,2-Tetrachloroethane	<5					
Toluene, ug/l	<5					
Ethyl methacrylate, ug/l	<5					
Chlorobenzene, ug/l	<5					
ethylbenzene, ug/l	<5					
Styrene,m ug/l	<5					
Xylenes (total), ug/l	<5					
2-Chloroethyl vinyl ether,mg	<10					

COMMENTS:

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: M-4

DATE SAMPLED		7\09\90						
FIELD TESTS (Sampled by)		SM & SP						
LABORATORY		CHEN-NORTH.						MAX CONC LEVEL
Chloromethane, ug/l		<10						
Bromoethane, ug/l		<10						
Vinyl Chloride, ug?l		<10						
Dichlorodifluoromethane		<5						
Chloroethane, ug/l		<10						
Methyl iodide, ug/l		<5						
Acrolein, mg/l		<100						
Acrylonitrile, ug/l		<100						
Methylene Chloride, ug/l		<5						
Acetone, ug/l		<100						
Trichlorofluoromethane, ug/l		<5						
Carbon Disulfide, ug/l		<100						
1,1-Dichloroethene, ug/l		<5						
Chloroform, ug/l		<5						
1,2-Dichloroethane, ug/l		<5						
2-Butanone, ug/l		<100						
Dibromomethane, ug/l		<5						
1,1,1-Trichloroethane, ug/l		<5						

COMMENTS:

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: SHOP

DATE SAMPLED	7\18\81	5\18\82	11\21\82	5\31\83	6\30\83	11\2\83	5\30\84	
FIELD TESTS (Sampled by)	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	
PH	7.5	7.9	8.3	7.5	7.5	7.6	7.72	
SPECIFIC CONDUCTIVITY	238	310	388	376	440	390	220	
TEMPERATURE (degrees c)								
DISSOLVED OXYGEN (mg/l)								
STATIC H2O LEVEL (ft.)	NA	NA	NA	NA	NA	NA	NA	
LABORATORY	MSU ANAL.	MSU LAB	MSU ANAL.	MSU LAB	CITY LAB	CITY LAB	CITY LAB	MSU ANAL.	MSU LAB	MAX CONC LEVEL
Chloride as Cl, mg/l	6.8	7.2	4.9	5	9.7	9	1			250
Nitrate + Nitrite as N, mg/l	.45	.53	.45							10
Sulfate as SO4, mg/l	1.3	2.6								250
Chemical Oxygen Demand, mg/l	103.6	25.2	71.4		2.4	2.4	1.6			
Total Cyanide as CN, ug/l	40	40								
DISSOLVED METALS, mg/l										
Arsenic as As, ug/l	.01	.01								.05
Cadmium as Cd, ug/l	1	1								.1
Chromium as Cr, ug/l	.02	.06	.06	.08	.01	.01				.05
Iron as Fe	.03	.03								.3
Lead as Pb										.05
Magnesium as Mg	17.5	9.3								
Manganese as Mn	.01	.01								.05
Nickel as Ni, ug/l	1	4.8								
Zinc as Zn	.18	.05								
Calcium as Ca	39.9	45								
Sodium as Na	8	7.9								
Copper as Cu	.02	.02								
Total Hg, ug/l	.02	.02								
Alkalinity as CaCO3	182.4	178	172.8							
Total Organic Carbon, mg/l										
Total Organic Halogens, ug/l										
Total Dissolved Solids	194	218	237	204	224	248	224			

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: SHOP

DATE SAMPLED	11\21\84	5\17\85	11\11\85	5\08\86	8\11\87	12\03\87	5\26\88	
FIELD TESTS (Sampled by)	CITY BOZE	CITY BOZE	CITY BOZE	CITY BOZE	JS & SB	JS & SB	JS & SB	
PH	7.7	6.8	7.4	7.7	7.6	7.8	7.4	
SPECIFIC CONDUCTIVITY	320	350	310	290	360	360	380	
TEMPERATURE (degrees c)				8	11	8.5	10	
DISSOLVED OXYGEN (mg/l)					9.2	5.2	6.6	
STATIC H2O LEVEL (ft.)					NR	NR	NR	
LABORATORY	MSU ANAL.	MSU LAB	MSU ANAL.	MSU LAB	ENERGY LABS	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	MAX CONC LEVEL
Chloride as Cl, mg/l	2.4	4.4	4	5	2	2	2	250
Nitrate + Nitrite as N, mg/l			.4	.41	.43	.31	.4	10
Sulfate as SO4, mg/l		10	9			4		250
Chemical Oxygen Demand, mg/l						<1		
Total Cyanide as CN, ug/l	37					<0.005		
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l				<0.1	<0.005	<0.005	<0.005	.05
Cadmium as Cd, ug/l				.001	.008	<0.005	.005	.1
Chromium as Cr, ug/l				<0.02	<0.02	<0.02	.02	.05
Iron as Fe				<0.03	.11	.25	.21	.3
Lead as Pb				<0.01	<0.02	<0.02	<0.02	.05
Magnesium as Mg				17				
Manganese as Mn				<0.02	.02	.05	.03	.05
Nickel as Ni, ug/l				<0.03	<0.02	<0.02	<0.02	
Zinc as Zn				.44	.13	.2	.17	
Calcium as Ca				43				
Sodium as Na				7				
Copper as Cu				<0.01				
Total Hg, ug/l								
Alkalinity as CaCO3								
Total Organic Carbon, mg/l			<2	<0.5	.7	5.1	.7	
Total Organic Halogens, ug/l								
Total Dissolved Solids	180	180	185	185				

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

GROUND WATER MONITORING

PREPARED FOR: CITY OF BOZEMAN

DATE: September 21, 1990

LOCATION: BOZEMAN LANDFILL

PREPARED BY: MORRISON -MAIERLE INC.
JOHN R. SCHUNKE
SCOTT T. BELL

WELL DESIGNATION: SHOP

DATE SAMPLED	11\14\88	5\15\89	6\05\89	10\06\89	7\09\90			
FIELD TESTS (Sampled by)	JS & SB	JS & SB	RS & SM	RS & SM	RS & SM			
PH	7.2	7	6.2	7.5	7.8			
SPECIFIC CONDUCTIVITY	360	370	390	380	385			
TEMPERATURE (degrees c)	8	12	12	10	9			
DISSOLVED OXYGEN (mg/l)	7.6	8.3	6.4	7.2	7.4			
STATIC H20 LEVEL (ft.)	NR	NR	NR	NR	NR			
LABORATORY	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.	NORTH. ENG.			MAX CONC LEVEL
Chloride as Cl, mg/l	<1	2	6	1	2			250
Nitrate + Nitrite as N, mg/l	.49	.37	.58	.45	.39			10
Sulfate as SO4, mg/l	7	5	6	3	3			250
Chemical Oxygen Demand, mg/l	4	<3	<2	<1	4			
Total Cyanide as CN, ug/l	37	<0.005	<0.005	<0.005	<0.005			
DISSOLVED METALS, mg/l								
Arsenic as As, ug/l	<0.005	<0.005	<0.005	<0.005	<0.005			.05
Cadmium as Cd, ug/l	<0.005	.006	<0.005	<0.005	<0.005			.1
Chromium as Cr, ug/l	<0.02	<0.02	<0.02	<0.02	<0.02			.05
Iron as Fe	.12	.07	.48	.18	.06			.3
Lead as Pb	<0.02	<0.02	<0.02	<0.02	<0.01			.05
Magnesium as Mg								
Manganese as Mn	.03	.03	.03	.04	.04			.05
Nickel as Ni, ug/l	<0.02	.03	<0.02	<0.02	.03			
Zinc as Zn	.09	.17	.68	.78	.32			
Calcium as Ca								
Sodium as Na								
Copper as Cu								
Total Hg, ug/l								
Alkalinity as CaCO3					.005			
Total Organic Carbon, mg/l	<0.5	<0.5	.7	.6	.7			
Total Organic Halogens, ug/l	7			<5				
Total Dissolved Solids			185					

COMMENTS:

STATIC WATER LEVEL MEASURED IN FEET BELOW THE TOP OF CASING

SAMPLING METHOD WAS WITH A PORTABLE PUMP

* The sample bottles broke during shipment

** To be reported upon completion

APPENDIX B

WATER SAMPLE ANALYSIS

JULY 1990

Chen-Northern, Inc.

A member of the HIH group of companies

600 SOUTH 25TH STREET
P. O. BOX 30615
BILLINGS, MT 59107
(406) 248-9161
FAX (406) 248-9282

TECHNICAL REPORT

REPORT TO: MORRISON-MAIERLE, INC.
ATTN: MR. SCOTT BELL
P O BOX 1113
BOZEMAN, MT 59715

DATE: September 13, 1990
JOB NUMBER: 79-922
SHEET: 1 OF 6
INVOICE NO.: 103808

REPORT OF: Water Analysis - Bozeman Landfill

Sample Identification:

On July 11, 1990, these water samples (laboratory numbers 105539 - 105546) were received in our laboratory for analysis. Tests were conducted in accordance with the U.S. Environmental Protection Agency Manual EPA 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes." The results of the analysis are shown on the following pages. A portion of each sample was sent to Lancaster Laboratories, Inc. of Lancaster, Pennsylvania for analysis using gas chromatography/mass spectrometry techniques. A quality assurance summary is enclosed.

A < sign indicates less than the reported value was present in the sample.

Reviewed by Kathleen A. Smith

Enclosure

rmr

WATER ANALYSIS
BOZEMAN LANDFILL
MORRISON-MAIERLE, INC.

September 13, 1990
Job No. 79-922

Lab No.:	105539	105540	105543
Sample Description:	M-1	M-2	LF-1
Date Sampled:	7/09/90	7/10/90	7/09/90
Collected by:	Not Given	Not Given	Not Given
All in mg/l			
Chloride as Cl	6	16	24
Nitrate+Nitrite as N	4.26	3.14	3.20
Sulfate as SO_4	9	7	13
Chemical Oxygen Demand	12	10	16
Total Cyanide as CN	<0.005	<0.005	<0.005
Total Organic Carbon	1.3	1.3	3.5
Total Organic Halogens	0.008	0.031	0.025
Dissolved Metals, mg/l			
Arsenic as As	<0.005	<0.005	<0.005
Cadmium as Cd	<0.005	<0.005	<0.005
Chromium as Cr	0.02	<0.02	<0.02
Iron as Fe	14.6	0.34	1.99
Lead as Pb	<0.01	<0.01	<0.01
Manganese as Mn	0.36	0.20	0.16
Nickel as Ni	0.03	0.02	0.03
Zinc as Zn	0.05	<0.02	0.07

WATER ANALYSIS
BOZEMAN LANDFILL
MORRISON-MAIERLE, INC.

September 13, 1990
Job No. 79-922

Lab No.:	105544	105545	105546
Sample Description:	LF-2	LF-3	Shop
Date Sampled:	7/09/90	7/09/90	7/09/90
Collected by:	Not Given	Not Given	Not Given
All in mg/l			
Chloride as Cl	18	8	2
Nitrate+Nitrite as N	3.42	2.46	0.39
Sulfate as SO_4	4	4	3
Chemical Oxygen Demand	12	12	4
Total Cyanide as CN	<0.005	<0.005	<0.005
Total Organic Carbon	2.3	2.5	0.7
Total Organic Halogen	0.010	0.014	0.005
Dissolved Metals, mg/l			
Arsenic as As	<0.005	<0.005	<0.005
Cadmium as Cd	<0.005	<0.005	<0.005
Chromium as Cr	<0.02	<0.02	<0.02
Iron as Fe	0.08	0.75	0.06
Lead as Pb	<0.01	<0.01	<0.01
Manganese as Mn	0.05	0.07	0.04
Nickel as Ni	0.03	0.05	0.03
Zinc as Zn	0.03	0.05	0.32

WATER ANALYSIS
BOZEMAN LANDFILL
MORRISON-MAIERLE, INC.

September 13, 1990
Job No. 79-922

Lab No.:	105541	105542
Sample Description:	M-3	M-4
Date Sampled:	7/09/90	7/10/90
Collected by:	Not Given	Not Given
Ammonia Nitrogen as N, mg/l	<0.20	<0.20
Total Alkalinity as $CaCO_3$, mg/l	365	390
Calcium as Ca, mg/l	97	100
Chloride as Cl, mg/l	23	10
Iron as Fe, mg/l	0.08	0.12
Magnesium as Mg, mg/l	34	33
Manganese as Mn, mg/l	0.06	0.06
Nitrate + Nitrite as N, mg/l	2.16	2.24
Potassium as K, mg/l	<1	1
Sodium as Na, mg/l	12	12
Sulfate as SO_4, mg/l	9	13
Chemical Oxygen Demand, mg/l	14	4
Total Dissolved Solids, mg/l	452	429
Total Cyanide as CN, mg/l	<0.005	<0.005
Total Organic Carbon, mg/l	2.8	2.6
pH, standard units	7.1	7.3
Dissolved Arsenic as As, mg/l	<0.005	<0.005
Dissolved Beryllium as Be, mg/l	0.010	0.010
Dissolved Cadmium as Cd, mg/l	<0.005	<0.005
Dissolved Chromium as Cr, mg/l	<0.02	<0.02
Dissolved Lead as Pb, mg/l	<0.01	<0.01
Dissolved Mercury as Hg, mg/l	<0.0002	<0.0002
Dissolved Selenium as Se, mg/l	<0.005	<0.005
Dissolved Silver as Ag, mg/l	<0.001	<0.001
Bromochloromethane, µg/l	<5	<5
1,4 Difluorobenzene, µg/l	<5	<5
Ethanol, µg/l	<1000	<1000
4 Bromofluorobenzene, µg/l	<5	<5
Carbon Tetrachloride, µg/l	<5	<5
Vinyl Acetate, µg/l	<50	<50
Bromodichloromethane, µg/l	<5	<5
trans-1,3-Dichloropropene, µg/l	<5	<5
Trichloroethene, µg/l	<5	<5
1,1,2-Trichloroethane, µg/l	<5	<5
Benzene, µg/l	<5	<5
cis-1,3-Dichloropropene, µg/l	<5	<5
Bromoform, µg/l	<5	<5
trans-1,4-dichloro-2-butene, µg/l	<100	<100
1,2,3-Trichloropropane, µg/l	<5	<5

WATER ANALYSIS
BOZEMAN LANDFILL
MORRISON-MAIERLE, INC.

September 13, 1990
Job No. 79-922

Lab No.:	105541	105542
Sample Description:	M-3	M-4
Date Sampled:	7/09/90	7/10/90
Collected by:	Not Given	Not Given
2-Hexanone, µg/l	<50	<50
4-Methyl-2-Pentanone, µg/l	<50	<50
1,1,2,2-Tetrachloroethane, µg/l	<5	<5
Toluene, µg/l	<5	<5
Ethyl methacrylate, µg/l	<5	<5
Chlorobenzene, µg/l	<5	<5
Ethylbenzene, µg/l	<5	<5
Styrene, µg/l	<5	<5
Xylenes (total), µg/l	<5	<5
2-Chloroethyl vinyl ether, µg/l	<10	<10
Chloromethane, µg/l	<10	<10
Bromoethane, µg/l	<10	<10
Vinyl Chloride, µg/l	<10	<10
Dichlorodifluoromethane, µg/l	<5	<5
Chloroethane, µg/l	<10	<10
Methyl iodide, µg/l	<5	<5
Acrolein, µg/l	<100	<100
Acrylonitrile, µg/l	<100	<100
Methylene Chloride, µg/l	<5	<5
Acetone, µg/l	<100	<100
Trichlorofluoromethane, µg/l	<5	<5
Carbon Disulfide, µg/l	<100	<100
1,1-Dichloroethene, µg/l	<5	<5
1,1-Dichloroethane, µg/l	<5	<5
Chloroform, µg/l	<5	<5
1,2-Dichloroethane, µg/l	<5	<5
2-Butanone, µg/l	<100	<100
Dibromomethane, µg/l	<5	<5
1,1,1-Trichloroethane, µg/l	<5	<5

WATER ANALYSIS
BOZEMAN LANDFILL
MORRISON-MAIERLE, INC.

September 13, 1990
Job No. 79-922
Sheet 6 of 6

Lab No.:	105542	105541
Sample Description:	Duplicate	Spike
Date Sampled:	7/10/90	7/09/90
Collected by:	Not Given	Not Given
Ammonia Nitrogen as N, mg/l	<0.20	100%
Total Alkalinity as $CaCO_3$, mg/l	402	100%
Calcium as Ca, mg/l	104	93%
Chloride as Cl, mg/l	12	107%
Iron as Fe, mg/l	0.12	97%
Magnesium as Mg, mg/l	34	87%
Manganese as Mn, mg/l	0.06	97%
Nitrate + Nitrite as N, mg/l	2.20	99%
Potassium as K, mg/l	-	-
Sodium as Na, mg/l	11	90%
Sulfate as SO_4, mg/l	12	99%
Chemical Oxygen Demand, mg/l	4	82%
Total Dissolved Solids, mg/l	423	-
Total Cyanide as CN, mg/l	<0.005	96%
Total Organic Carbon, mg/l	-	-
pH, standard units	7.3	-
Dissolved Arsenic as As, mg/l	<0.005	113%
Dissolved Beryllium as Be, mg/l	0.009	97%
Dissolved Cadmium as Cd, mg/l	<0.005	105%
Dissolved Chromium as Cr, mg/l	<0.02	118%
Dissolved Lead as Pb, mg/l	<0.01	107%
Dissolved Mercury as Hg, mg/l	0.0002	-
Dissolved Selenium as Se, mg/l	<0.005	107%
Dissolved Silver as Ag, mg/l	<0.001	88%
Bromochloromethane, µg/l	<5	85%*
1,4 Difluorobenzene, µg/l	<5	85%*
Ethanol, µg/l	<1000	85%*
4 Bromofluorobenzene, µg/l	<5	85%*

*Surrogate Recovery

QUALITY ASSURANCE SUMMARY

CLIENT: Chen-Northern, Inc. - Billings

P.O.# 63873

PROJECT: #105542 Water Samples

COLLECTED: 07/09/90

LLI Sample #: 1547644-1547645

Questions? Contact Environmental Client Services at (717) 656-2301

VOLATILES DATA

Lancaster Laboratories INCORPORATED
Where quality is a science

WATER VOLATILE SURROGATE RECOVERY

2A

Lab Name: LANCASTER LABS Contract:

Lab Code: Case No: SAS No: SDG No:

	LLI SAMPLE NO.	S1 (DCE) #	S2 (TOL) #	S3 (BFB) #	OTHER	TOT OUT	COMMENTS
01	1547644	92	104	106			
02	1547645	93	105	107			
03							
04							
05							
06							
07							
08							
09							
10							
11							
12							
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15							
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17							
18							
19							
20							
21							
22							
23							
24							
25							

				QC LIMITS
S1	(DCE)	=	1,2-Dichloroethane-d4	76 - 114
S2	(TOL)	=	Toluene-d8	88 - 110
S3	(BFB)	=	Bromofluorobenzene	86 - 115

\# Column to be used to flag recovery values

* Values outside of contract required QC limits

D Surrogates diluted out

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

METHOD BLK

Lab Name: LancasterLabs Contract: -----

Lab Code: LANCAS Case No.: ----- SAS No.: ----- SDG No.: ------

Matrix: (soil/water) WATER Lab Sample ID: METHOD BLK

Sample wt/vol: 5.0 (g/mL) mL Lab File ID: >JB227

Level: (low/med) LOW Date Received: 6/27/90

% Moisture: not dec.____ Date Analyzed: 6/27/90

Column: (pack/cap) PACK Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) ug/L	Q
74-87-3	Chloromethane	10.	U
74-83-9	Bromomethane	10.	U
75-01-4	Vinyl Chloride	10.	U
75-43-4	Dichlorodifluoromethane	5.	U
75-00-3	Chloroethane	10.	U
74-88-4	Methyl Iodide	5.	U
107-02-8	Acrolein	100.	U
107-13-1	Acrylonitrile	100.	U
75-05-8	Acetonitrile	100.	U
75-09-2	Methylene_Chloride	5.	U
67-64-1	Acetone	100.	U
75-69-4	Trichlorofluoromethane	5.	U
75-15-0	Carbon Disulfide	100.	U
107-12-0	Propionitrile	100.	U
75-35-4	1,1-Dichloroethene	5.	U
107-05-1	Allyl Chloride	5.	U
75-34-3	1,1-Dichloroethane	5.	U
540-59-0	trans-1,2-Dichloroethene	5.	U
67-66-3	Chloroform	5.	U
107-02-2	1,2-Dichloroethane	5.	U
126-98-7	Methacrylonitrile	100.	U
78-93-3	2-Butanone	100.	U
74-95-3	Dibromomethane	5.	U
71-55-6	1,1,1-Trichloroethane	5.	U
123-91-1	1,4-Dioxane	100.	U
56-23-5	Carbon Tetrachloride	5.	U
78-83-1	Isobutyl Alcohol	250.	U
108-05-4	Vinyl Acetate	50.	U
75-27-4	Bromodichloromethane	5.	U
126-99-8	2-Chloro-1,3-butadiene	5.	U
78-87-5	1,2-Dichloropropane	5.	U
10061-02-6	trans-1,3-Dichloropropene	5.	U
79-01-6	Trichloroethene	5.	U
124-48-1	Dibromochloromethane	5.	U
79-00-5	1,1,2-Trichloroethane	5.	U
106-93-4	1,2-Dibromoethane	5.	U
71-43-2	Benzene	5.	U
10061-01-5	cis-1,3-Dichloropropene	5.	U
110-75-8	2-Chloroethyl Vinyl Ether	10	U

591-78-6--------2-Hexanone	50.	U
108-10-1--------4-Methyl-2-pentanone	50.	U
127-18-4--------Tetrachloroethene	5.	U
79-34-5---------1,1,2,2-Tetrachloroethane	5.	U
108-88-3--------Toluene	5.	U
97-63-2---------Ethyl Methacrylate	5.	U
108-90-7--------Chlorobenzene	5.	U
76-01-7---------Pentachloroethane	10.	U
100-41-4--------Ethylbenzene	5.	U
96-12-8---------1,2-Dibromo-3-chloropropane	100.	U
100-42-5--------Styrene	5.	U
1330-20-7-------Xylene(Total)	5.	U
1634-04-4-------Methyl t-Butyl Ether	5.	U

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

METHOD BLK

Lab Name: LancasterLabs Contract: -----

Lab Code: LANCAS Case No.: ----- SAS No.: ----- SDG No.: ------

Matrix: (soil/water) WATER Lab Sample ID: METHOD BLK

Sample wt/vol: 5.0 (g/mL) mL Lab File ID: >LB219

Level: (low/med) LOW Date Received: 7/19/90

% Moisture: not dec._____ Date Analyzed: 7/19/90

Column: (pack/cap) PACK Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) ug/L	Q
74-87-3	Chloromethane	10.	U
74-83-9	Bromomethane	10.	U
75-01-4	Vinyl Chloride	10.	U
75-43-4	Dichlorodifluoromethane	5.	U
75-00-3	Chloroethane	10.	U
74-88-4	Methyl Iodide	5.	U
107-02-8	Acrolein	100.	U
107-13-1	Acrylonitrile	100.	U
75-05-8	Acetonitrile	100.	U
75-09-2	Methylene Chloride	5.	U
67-64-1	Acetone	100.	U
75-69-4	Trichlorofluoromethane	5.	U
75-15-0	Carbon Disulfide	100.	U
107-12-0	Propionitrile	100.	U
75-35-4	1,1-Dichloroethene	5.	U
107-05-1	Allyl Chloride	5.	U
75-34-3	1,1-Dichloroethane	5.	U
540-59-0	trans-1,2-Dichloroethene	5.	U
67-66-3	Chloroform	5.	U
107-02-2	1,2-Dichloroethane	5.	U
126-98-7	Methacrylonitrile	100.	U
78-93-3	2-Butanone	100.	U
74-95-3	Dibromomethane	5.	U
71-55-6	1,1,1-Trichloroethane	5.	U
123-91-1	1,4-Dioxane	100.	U
56-23-5	Carbon Tetrachloride	5.	U
78-83-1	Isobutyl Alcohol	250.	U
108-05-4	Vinyl Acetate	50.	U
75-27-4	Bromodichloromethane	5.	U
126-99-8	2-Chloro-1,3-butadiene	5.	U
78-87-5	1,2-Dichloropropane	5.	U
10061-02-6	trans-1,3-Dichloropropene	5.	U
79-01-6	Trichloroethene	5.	U
124-48-1	Dibromochloromethane	5.	U
79-00-5	1,1,2-Trichloroethane	5.	U
106-93-4	1,2-Dibromoethane	5.	U
71-43-2	Benzene	5.	U

110-57-6--------trans-1,4-Dichloro-2-butene_	100.	U
96-18-4---------1,2,3-Trichloropropane_____	5.	U
591-78-6--------2-Hexanone_____	50.	U
108-10-1--------4-Methyl-2-pentanone_____	50.	U
127-18-4--------Tetrachloroethene_____	5.	U
79-34-5---------1,1,2,2-Tetrachloroethane____	5.	U
108-88-3--------Toluene_____	5.	U
97-63-2---------Ethyl Methacrylate_____	5.	U
108-90-7--------Chlorobenzene_____	5.	U
76-01-7---------Pentachloroethane_____	10.	U
100-41-4--------Ethylbenzene_____	5.	U
96-12-8---------1,2-Dibromo-3-chloropropane_	100.	U
100-42-5--------Styrene_____	5.	U
1330-20-7-------Xylene(Total)_____	5.	U

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLE RECOVERY

Lab Name: LANCASTER LABS Lab Code: LANCAS

SW846 METHOD 8240 SPIKE LEVEL: 20 UG/L AMT USED: 5.0

SAMPLE SPIKE LEVEL: 20.ug/L % MOISTURE 0. DILUTION: 1

US SAMPLE: 1536723 WE13A MS SAMPLE: 1536723 WE13AMS MSD SAMPLE: 1536723 WE13AMSD

COMPOUND NAME	US CONC ug/L	MS CONC ug/L	MSD CONC ug/L	MS REC %	MSD REC %	RPD %	RANGE LOWER-UPPER	IN SPEC
CHLOROMETHANE	0.	26.	25.	132	127	4.00	2.0-273.0	YES
BROMOMETHANE	0.	24.	23.	118	115	3.00	2.0-242.0	YES
VINYL CHLORIDE	0.	23.	22.	116	112	4.00	2.0-251.0	YES
DICHLORODIFLUOROMETHANE	0.	24.	26.	122	129	-6.00	30.0-200.0	YES
CHLOROETHANE	0.	25.	22.	125	110	13.00	50.0-150.0	YES
METHYL IODIDE	0.	17.	17.	85	84	1.00	30.0-200.0	YES
ACROLEIN	0.	70.	67.	83	79	5.00	50.0-150.0	YES
ACRYLONITRILE	0.	88.	95.	96	104	-8.00	50.0-150.0	YES
ACETONITRILE	0.	93.	91.	93	91	2.00	30.0-200.0	YES
METHYLENE CHLORIDE	0.	21.	20.	103	102	1.00	2.0-221.0	YES
ACETONE	5.	52.	59.	104	117	-12.00	30.0-200.0	YES
TRICHLOROFLUOROMETHANE	0.	22.	21.	111	107	4.00	17.0-181.0	YES
CARBON DISULFIDE	0.	29.	28.	58	55	5.00	30.0-200.0	YES
PROPIONITRILE	0.	93.	112.	93	112	-19.00	30.0-200.0	YES
1,1-DICHLOROETHENE	18.	39.	37.	104	93	11.00	2.0-234.0	YES
ALLYL CHLORIDE	0.	18.	18.	88	92	-4.00	30.0-200.0	YES
1,1 DICHLOROETHANE	4.	26.	25.	111	108	3.00	59.0-155.0	YES
TRANS-1,2 DICHLOROETHENE	19.	39.	37.	100	92	8.00	54.0-156.0	YES
CHLOROFORM	1.	24.	23.	112	106	6.00	51.0-138.0	YES
1,2-DICHLOROETHANE	0.	23.	22.	114	111	3.00	49.0-155.0	YES
METHACRYLONITRILE	0.	50.	51.	100	103	-3.00	30.0-200.0	YES
METHYL T BUTYL ETHER	0.	22.	23.	109	113	-4.00	30.0-200.0	YES
2-BUTANONE	0.	48.	55.	95	110	-15.00	30.0-200.0	YES
DIBROMOMETHANE	0.	20.	19.	99	94	5.00	30.0-200.0	YES
1,1,1-TRICHLOROETHANE	106.	125.	111.	95	25	117.00	52.0-162.0	NO
1,4-DIOXANE	0.	18.	189.	18	189	-135.00	30.0-200.0	NO
CARBON TETRACHLORIDE	0.	20.	19.	99	94	5.00	70.0-140.0	YES
ISOBUTYL ALCOHOL	0.	157.	280.	78	140	-57.00	30.0-200.0	YES
VINYL ACETATE	0.	49.	47.	98	94	4.00	30.0-200.0	YES
BROMODICHLOROMETHANE	0.	21.	20.	106	100	6.00	35.0-155.0	YES
2-CHLORO-1,3-BUTADIENE	0.	20.	19.	101	95	6.00	30.0-200.0	YES
1,2-DICHLOROPROPANE	0.	22.	21.	110	105	5.00	2.0-210.0	YES
CIS-1,3-DICHLOROPROPENE	0.	20.	18.	98	91	7.00	2.0-227.0	YES
TRICHLOROETHENE	110.	129.	116.	97	32	101.00	71.0-157.0	NO
DIBROMOCHLOROMETHANE	0.	19.	18.	95	89	7.00	53.0-149.0	YES
1,1,2-TRICHLOROETHANE	0.	23.	22.	114	108	5.00	52.0-150.0	YES
1,2-DIBROMOETHANE	0.	20.	19.	98	95	3.00	30.0-200.0	YES
BENZENE	0.	21.	20.	107	102	5.00	37.0-151.0	YES
TRANS-1,3 DICHLOROPROPENE	0.	11.	11.	96	97	-1.00	17.0-183.0	YES

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLE RECOVERY

Lab Name: LANCASTER LABS Lab Code: LANCAS

SW846 METHOD 8240 SPIKE LEVEL: 20 UG/L AMT USED: 5.0

SAMPLE SPIKE LEVEL: 20.ug/L % MOISTURE 0. DILUTION: 1

US SAMPLE: 1536723 WE13A MS SAMPLE: 1536723 WE13AMS MSD SAMPLE: 1536723 WE13AMSD

COMPOUND NAME	US CONC ug/L	MS CONC ug/L	MSD CONC ug/L	MS REC %	MSD REC %	RPD %	RANGE LOWER-UPPER	IN SPEC
METHYL METHACRYLATE	0.	25.	24.	126	122	3.00	30.0-200.0	YES
1,1,1,2-TETRACHLOROETHANE	0.	20.	18.	101	92	9.00	30.0-200.0	YES
BROMOFORM	0.	18.	17.	91	86	6.00	45.0-169.0	YES
TRANS-1,4-DICHLORO-2-BUTENE	0.	74.	73.	96	94	2.00	30.0-200.0	YES
1,2,3-TRICHLOROPROPANE	0.	22.	23.	112	115	-3.00	30.0-200.0	YES
2-HEXANONE	0.	52.	65.	103	129	-22.00	30.0-200.0	YES
4-METHYL-2-PENTANONE	0.	53.	63.	107	127	-17.00	30.0-200.0	YES
TETRACHLOROETHENE	5.	27.	26.	108	104	4.00	64.0-148.0	YES
1,1,2,2-TETRACHLOROETHANE	0.	23.	23.	113	116	-3.00	46.0-157.0	YES
TOLUENE	0.	23.	23.	116	116	0.00	47.0-150.0	YES
ETHYL METHACRYLATE	0.	22.	22.	112	112	0.00	30.0-200.0	YES
CHLOROBENZENE	0.	23.	22.	117	111	5.60	37.0-160.0	YES
PENTACHLOROETHANE	0.	21.	21.	103	103	0.00	30.0-200.0	YES
ETHYLBENZENE	0.	23.	24.	116	118	-2.00	37.0-162.0	YES
1,2-DIBROMO-3-CHLOROPROPANE	0.	48.	55.	97	110	-13.00	30.0-200.0	YES
STYRENE	0.	22.	21.	112	107	5.00	30.0-200.0	YES
XYLENE (TOTAL)	0.	23.	22.	117	112	4.00	30.0-200.0	YES

SPECIAL SPIKE LEVELS	(UG/L)
ACROLEIN	84
ACRYLONITRILE	92
ACETONITRILE	100
ACETONE	50
CARBON DISULFIDE	50
PROPIONITRILE	100
METHACRYLONITRILE	50
2-BUTANONE	50
1,4-DIOXANE	100
ISOBUTYL ALCOHOL	200
VINYL ACETATE	50
TRANS-1,3-DICHLOROPROPENE	11.3
TRANS-1,4-DICHLORO-2-BUTENE	76.8
2-HEXANONE	50
4-METHYL-2-PENTANONE	50
1,2-DIBROMO-3-CHLOROPROPANE	50

WATER VOLATILE QUALITY CONTROL REFERENCE SAMPLE RECOVERY

LAB NAME: LANCASTER LABS LAB CODE: LANCAS ANALYSES: 1265/1266

SW846 METHOD 8240 SPIKE LEVEL: 20 UG/L BATCH 90177-146-07-02900-2

LCS SAMPLE NO: LCS BKG= 1536723 WE3 WE13A MS= 1536723 WE13AMS MSD= 1536723 WE13AMSD

COMPOUND NAME	QCREF CONC UG/L	QCREF REC %	RANGE LOWER-UPPER	IN SPEC
CHLOROMETHANE	22.27	111	2.0- 273.0	YES
BROMOMETHANE	22.98	115	2.0- 242.0	YES
VINYL CHLORIDE	22.73	114	2.0- 251.0	YES
DICHLORODIFLUOROMETHANE	24.22	121	30.0- 200.0	YES
CHLOROETHANE	24.04	120	50.0- 150.0	YES
METHYL IODIDE	16.61	83	30.0- 200.0	YES
ACROLEIN	58.66	70	50.0- 150.0	YES
ACRYLONITRILE	86.26	94	50.0- 150.0	YES
ACETONITRILE	91.39	91	30.0- 200.0	YES
METHYLENE CHLORIDE	21.26	106	2.0- 221.0	YES
ACETONE	57.61	115	30.0- 200.0	YES
TRICHLOROFLUOROMETHANE	21.20	106	17.0- 181.0	YES
CARBON DISULFIDE	27.00	54	30.0- 200.0	YES
PROPIONITRILE	106.35	106	30.0- 200.0	YES
1,1-DICHLOROETHENE	20.29	101	2.0- 234.0	YES
ALLYL CHLORIDE	18.67	93	30.0- 200.0	YES
1,1-DICHLOROETHANE	21.59	108	59.0- 155.0	YES
TRANS-1,2-DICHLOROETHENE	19.30	97	54.0- 156.0	YES
CHLOROFORM	21.39	107	51.0- 138.0	YES
1,2-DICHLOROETHANE	21.41	107	49.0- 155.0	YES
METHACRYLONITRILE	53.10	106	30.0- 200.0	YES
METHYL T-BUTYL ETHER	21.89	109	30.0- 200.0	YES
2-BUTANONE	55.63	111	30.0- 200.0	YES
DIBROMOMETHANE	19.63	98	30.0- 200.0	YES
1,1,1-TRICHLOROETHANE	20.77	104	52.0- 162.0	YES
1,4-DIOXANE	164.36	164	30.0- 200.0	YES
CARBON TETRACHLORIDE	19.75	99	70.0- 140.0	YES
ISOBUTYL ALCOHOL	307.38	154	30.0- 200.0	YES
VINYL ACETATE	48.50	97	30.0- 200.0	YES
BROMODICHLOROMETHANE	21.20	106	35.0- 155.0	YES
2-CHLORO-1,3-BUTADIENE	18.98	95	30.0- 200.0	YES
1,2-DICHLOROPROPANE	22.02	110	2.0- 210.0	YES
CIS-1,3-DICHLOROPROPENE	19.02	95	2.0- 227.0	YES
TRICHLOROETHENE	21.44	107	71.0- 157.0	YES
DIBROMOCHLOROMETHANE	19.27	96	53.0- 149.0	YES
1,1,2-TRICHLOROETHANE	22.03	110	52.0- 150.0	YES
1,2-DIBROMOETHANE	19.79	99	30.0- 200.0	YES
BENZENE	21.90	110	37.0- 151.0	YES
TRANS-1,3-DICHLOROPROPENE	11.41	101	17.0- 183.0	YES

WATER VOLATILE QUALITY CONTROL REFERENCE SAMPLE RECOVERY

LAB NAME: LANCASTER LABS LAB CODE: LANCAS ANALYSES : 1265/1266

SW846 METHOD 8240 SPIKE LEVEL: 20 UG/L BATCH : 90177-146-07-02900-2

LCS SAMPLE NO: LCS BKG = 1536723 WE13A MS = 1536723 WE13AMS MSD = 1536723 WE13AMSD

COMPOUND NAME	QCREF CONC UG/L	QCREF REC %	RANGE LOWER-UPPER	IN SPEC
METHYL METHACRYLATE	26.02	130	30.0- 200.0	YES
1,1,1,2-TETRACHLOROETHANE	19.97	100	30.0- 200.0	YES
BROMOFORM	19.01	95	45.0- 169.0	YES
TRANS-1,4-DICHLORO-2-BUTENE	76.16	99	30.0- 200.0	YES
1,2,3-TRICHLOROPROPANE	24.68	123	30.0- 200.0	YES
2-HEXANONE	66.33	133	30.0- 200.0	YES
4-METHYL-2-PENTANONE	61.85	124	30.0- 200.0	YES
TETRACHLOROETHENE	23.63	118	64.0- 148.0	YES
1,1,2,2-TETRACHLOROETHANE	23.36	117	46.0- 157.0	YES
TOLUENE	23.41	117	47.0- 150.0	YES
ETHYL METHACRYLATE	23.11	116	30.0- 200.0	YES
CHLOROBENZENE	22.52	113	37.0- 160.0	YES
PENTACHLOROETHANE	19.11	96	30.0- 200.0	YES
ETHYLBENZENE	23.72	119	37.0- 162.0	YES
1,2-DIBROMO-3-CHLOROPROPANE	54.82	110	30.0- 200.0	YES
STYRENE	22.64	113	30.0- 200.0	YES
XYLENE (TOTAL)	23.33	117	30.0- 200.0	YES

SPECIAL SPIKE LEVELS	(UG/L)
ACROLEIN	84
ACRYLONITRILE	92
ACETONITRILE	100
ACETONE	50
CARBON DISULFIDE	50
PROPIONITRILE	100
METHACRYLONITRILE	50
2-BUTANONE	50
1,4-DIOXANE	100
ISOBUTYL ALCOHOL	200
VINYL ACETATE	50
TRANS-1,3-DICHLOROPROPENE	11.3
TRANS-1,4-DICHLORO-2-BUTENE	76.8
2-HEXANONE	50
4-METHYL-2-PENTANONE	50
1,2-DIBROMO-3-CHLOROPROPANE	50

INSTRUMENTAL ANALYSIS DATA

2E+06

Lancaster Laboratories
Where quality is a science.

Quality Control Summary

Method Blank
Instrumental Analysis Data

Sample Information		Method Blank Analysis				Matrix: WATER			
LLI Sample No.	Client Designation	Parameter	Method	Analysis Date	Meth Blank Desig.	Batch Number	Blank Result	Units	LOQ
1547644	M-3	Anion Scan							
1547645	M-4	Fluoride	IC				---	mg/L	
		Chloride	IC				---	mg/L	
		Nitrite-N	IC				---	mg/L	
		Bromide	IC				---	mg/L	
		Nitrate-N	IC				---	mg/L	
		Phosphate	IC				---	mg/L	
		Sulfate	IC				---	mg/L	
		Ammonia-N	TAA				---	mg/L	
		Chloride	IC				---	mg/L	
		Chlorine	IC				---	%	
		Cyanide	TAA				---	mg/L	
		Cyanide Reactivity	TAA				---	mg/Kg	
		Nitrite - N	IC				---	mg/L	
		Nitrate - N	IC				---	mg/L	
		Phenol	TAA				---	mg/L	
		Phosphorus	TAA				---	mg/L	
		Sulfate	IC				---	mg/L	
		TOC	TOC	07/25/90	BLANK	9020627352612909	ND	mg/L	0.5
		TOX	TOX				---	ug/L	
		Kjeldahl Nitrogen	TAA				---	mg/L	

Comments:

ABBREVIATION KEY

IC = Ion Chromatography	--- = Analysis not requested
TAA = Technicon AutoAnalyzer	ND = Not Detected
D = Distillation	J = Estimated Value below LOQ
TOC = Total Organic Carbon	LOQ = Limit of Quantitation
TOX = Total Organic Halogens	NA = Not Applicable

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Quality Control Summary

Matrix Spike Analysis
Instrumental Analysis Data

Sample Information		Matrix Spike Analysis										Matrix: WATER	
LLI Sample No.	Client Designation	Parameter	Meth	Analysis Date	Unspiked Desig.	Unspiked Result	LOQ	Spiked Desig.	Spike Added	Spiked Result	Units	%REC	
1547644	M-3	Anion Scan											
1547645	M-4	Fluoride	IC			---				---	mg/L		
		Chloride	IC			---				---	mg/L		
		Nitrite-N	IC			---				---	mg/L		
		Bromide	IC			---				---	mg/L		
		Nitrate-N	IC			---				---	mg/L		
		Phosphate	IC			---				---	mg/L		
		Sulfate	IC			---				---	mg/L		
		Ammonia-N	TAA			---				---	mg/L		
		Chloride	IC			---				---	mg/L		
		Chlorine	IC			---				---	%		
		Cyanide	TAA			---				---	mg/L		
		Cyanide Reactivity	TAA			---				---	mg/Kg		
		Nitrite - N	IC			---				---	mg/L		
		Nitrate - N	IC			---				---	mg/L		
		Phenol	TAA			---				---	mg/L		
		Phosphorus	TAA			---				---	mg/L		
		Sulfate	IC			---				---	mg/L		
		TOC	TOC	07/25/90	BKG	1.6	0.5	SPIKE	4.0	5.4	mg/L	95.7	
		TOX	TOX			---				---	ug/L		
		Kjeldahl Nitrogen	TAA			---				---	mg/L		

% Recovery Control Limit 75
% Recovery Control Limit 125

Comments:

ABBREVIATION KEY

IC = Ion Chromatography	--- = Analysis Not Requested
TAA = Technicon AutoAnalyzer	ND = Not Detected
D = Distillation	J = Estimated Value below LOQ
TOC = Total Organic Carbon	LOQ = Limit of Quantitation
TOX = Total Organic Halogens	NA = Not Applicable
	* = Out Of Specification

Lancaster Laboratories
Where quality is a science.

Quality Control Summary

Duplicate Analysis
Instrumental Analysis Data

Sample Information		Duplicate Analysis								Matrix: WATER				
LLI Sample No.	Client Designation	Parameter	Meth	Analysis Date	1st Dup Desig.	1st Dup Result	LOQ	2nd Dup Desig.	2nd Dup Result	Units	RPD (%)	Control Limit
1547644	M-3	Anion Scan										
1547645	M-4	Fluoride	IC			---			---	mg/L		20
		Chloride	IC			---			---	mg/L		20
		Nitrite-N	IC			---			---	mg/L		20
		Bromide	IC			---			---	mg/L		20
		Nitrate-N	IC			---			---	mg/L		20
		Phosphate	IC			---			---	mg/L		20
		Sulfate	IC			---			---	mg/L		20
		Ammonia-N	TAA			---			---	mg/L		20
		Chloride	IC			---			---	mg/L		20
		Chlorine	IC			---			---	%		20
		Cyanide	TAA			---			---	mg/L		20
		Cyanide										
		Reactivity	TAA			---			---	mg/Kg		20
		Nitrite - N	IC			---			---	mg/L		20
		Nitrate - N	IC			---			---	mg/L		20
		Phenol	TAA			---			---	mg/L		20
		Phosphorus	TAA			---			---	mg/L		20
		Sulfate	IC			---			---	mg/L		20
		TOC	TOC	07/25/90	BKG	1.6	0.5	DUP	1.6	mg/L	0	20
		TOX	TOX			---			---	ug/L		20
		Kjeldahl Nitrogen	TAA			---			---	mg/L		20

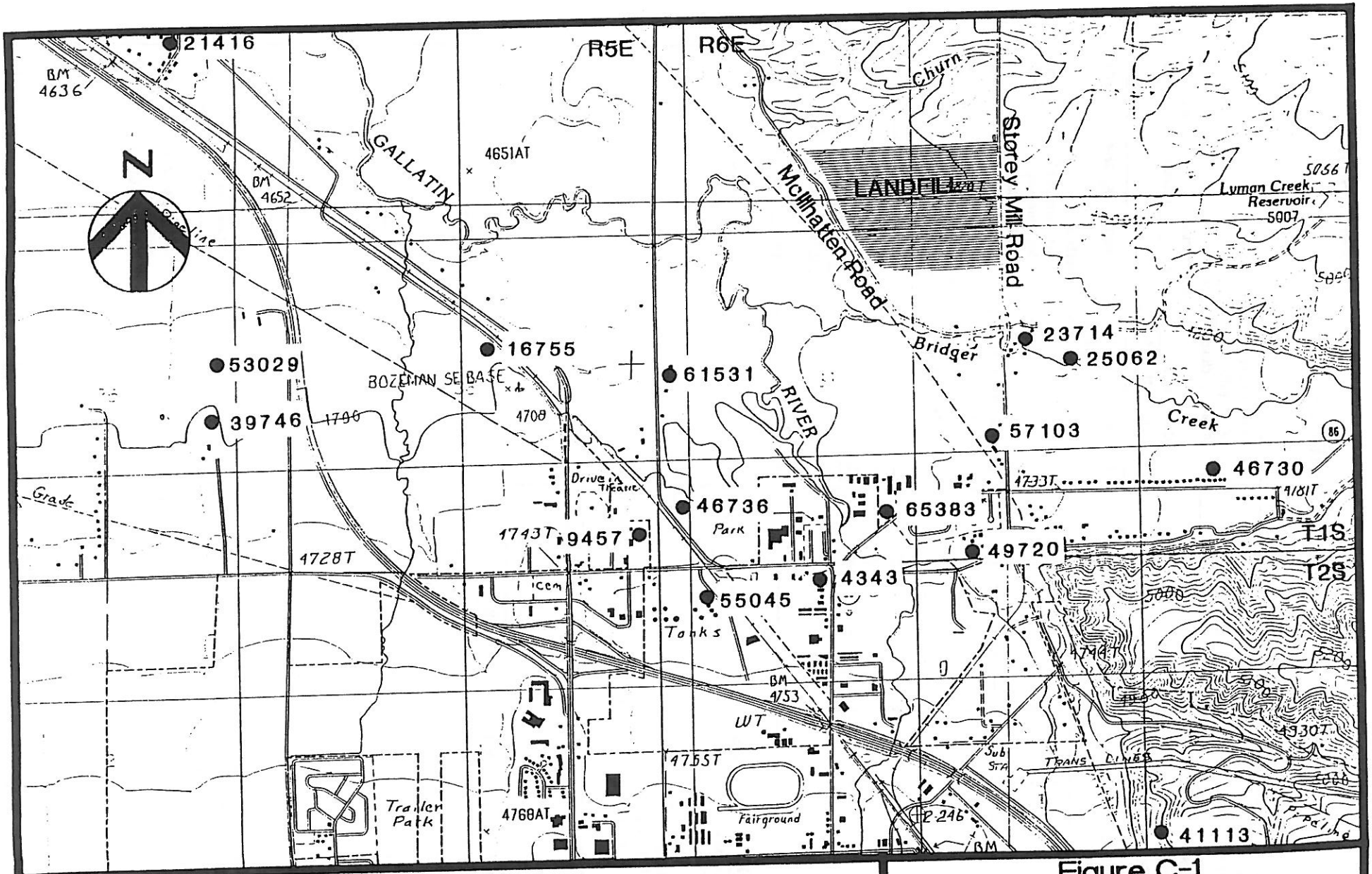
Comments:

ABBREVIATION KEY

IC = Ion Chromatography	---= Analysis Not Requested
TAA = Technicon AutoAnalyzer	ND = Not Detected
D = Distillation	J = Estimated Value below LC
TOC = Total Organic Carbon	LOQ= Limit of Quantitation
TOX = Total Organic Halogens	NA = Not Applicable
NR = Not Required	* = Out Of Specification

APPENDIX C

AREA DOMESTIC WELL LOG REPORTS



HDR

HDR Engineering, Inc.

Morrison Maierle/CSSA INC

Scale: 1"–2000'

Figure C-1
Area Well Locations
Bozeman Sanitary Landfill
Bozeman, Montana

File No 41113

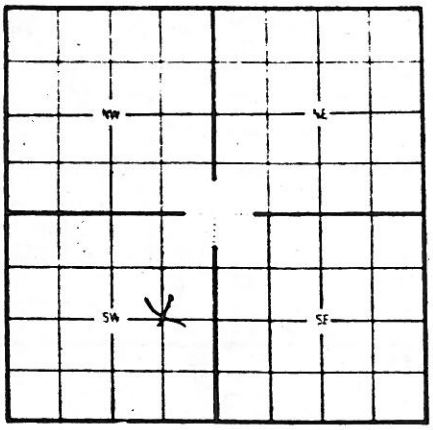
WELL LOG REPORT

State law requires that this form be filed with the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name Willie and Dorothy Figgins

2. CURRENT MAILING ADDRESS
1404 Bohart Lane
Bozeman, Montana

3. WELL LOCATION



XXXXXX E ¼ SW ¼ Section 5
Township 2S N/S Range 6E E/W
County Gallatin
Lot _____ Block _____
Subdivision _____
Well Elevation _____
Accuracy: ____ ±10'; ____ ±50'; ____ ±100';

4. DRILLING METHOD x cable, ____ bored, ____ forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) _____

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations ____ and/or Screen ____ Kind Size	From (feet)	To (feet)
6"	6" 17#	2'8"	52'8"			

9' 5" plastic liner set from 58-49'

Was casing left open end? x Yes ____ No
Was a packer or seal used? ____ Yes x No
If so, what material _____
Was the well gravel packed? ____ Yes x No
Was the well grouted? ____ Yes x No
To what depth? _____
Material used in grouting _____
Well head completion: Pitless adapter _____
12 in. above grade _____, other _____
(if other, specify) _____
Pump horsepower _____, pump type _____
Pump intake level _____ feet below land surface
Power (electric, diesel, etc.) _____

6. WATER LEVEL
Static water level 8 feet below land surface
If flowing, closed-in pressure _____ ps
_____ gpm flow through _____ inch pipe
Controlled by: _____ valve, _____ reducers, _____ other
(if other, specify) _____

7. WELL TEST DATA x pump x bailer ____ other
(if other, specify) _____
Pumping level below land surface:
35 ft. after 2 hrs. pumping 15 gpm
____ ft after ____ hrs pumping ____ gpm

8. WAS WELL PLUGGED OR ABANDONED? ____ Yes x No
If yes, how? _____

9. DATE STARTED March 6, 1971
DATE COMPLETED March 8, 1971

10. WELL LOG

Depth (ft.) From	To	Formation
0	38	dirty coarse sand & gravel
38	45	clay
45	58	sandstone

(use separate sheet if necessary)

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
October 30, 1981
Date
Potts Drilling and Developing
Firm Name
80730 Gallatin Rd. Bozeman, Montana 59715
Address
Herbert A. Potts
Signature
150
License No

4343

FORM

RECEIVED

SEP 16 1974

MONT. DEPT. OF NATURAL RESOURCES & CONSERVATION

STATE OF MONTANA
Department of Natural Resources and Conservation

WHITE —
PINK — BUREAU
CANARY — WELL
GOLDENROD — DRILLER

WELL LOG REPORT

Requires that this form be filled by the water well driller on any water well completed by him on and after July 1, 1973 within sixty (60) days after completion of the well.

1. WELL OWNER: Name Dale H. Nuss Address ~~xxx~~ Bozeman, Montana

2. WELL LOCATION: County Gallatin ; ~~xx~~ NE ¼ NW¼, Sec. 6, Twp. 2 ~~XX~~S, R. 5 E

3. PROPOSED USE: x Domestic ___ Stock ___ Municipal ___ Industrial ___ Lawn and Garden
___ Irrigation ___ Other (*if other, specify*) ___

4. METHOD DRILLED: x Cable ___ Bored
___ Forward Rotary ___ Reverse Rotary
___ Jetted ___ Other (*if other, specify*) ___

5. WELL CONSTRUCTION:
Diameter of hole 6 inches. Depth 190 ft.
Casing: ___ Steel ___ Plastic ___ Concrete
___ Threaded x Welded ___ Other (*if other, specify*) ___

Pipe Weight:	Dia.:	From:	To:
17 lb/ft.	6 inches	14" feet	56 feet
___ lb/ft.	___ inches	___ feet	___ feet
___ lb/ft.	___ inches	___ feet	___ feet

Was perforated pipe used? ___ Yes x No
Length of pipe perforated ___ feet
Was casing left open end? ___ Yes x No
Was a well screen installed? ___ Yes x No
Material ___ Dia. ___ inches
(*stainless steel, bronze, etc.*)
Perforation type: ___ slots ___ holes
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Was a packer or seal used? ___ Yes x No
If so, what material ___
Well type: ___ Straight screen ___ Graveled
Was the well grouted? ___ Yes x No
To what depth? ___ feet
Material used in grouting ___
Well head completion: Pitless adapter ___
12" above grade ___ Other ___
(*If other, specify*) ___
Was the well disinfected? ___ Yes x No

WATER LEVEL:
Static water level 45 ft. below land surface
If flowing: closed-in pressure ___ psi
Flow ___ through ___ inch pipe
Controlled by: ___ Valve ___ Reducers
___ Other, *specify* ___

TEST DATA: x Pump ___ Bailer ___ Other
(*other, specify*) ___
Pumping level below land surface:
0 ft. after 1 hrs. pumping 4 gpm
___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG:

Depth (ft.) From	Depth (ft.) To	Formation
1	45	clay
45	112	brown shale
112	115	blue shale
115	124	brown "
124	132	blue "
132	146	brown "
146	149	blue "
149	181	red "
181	190	blue "

(*Use separate sheet if necessary*)

9. DATE STARTED: June 24, 1974

10. DATE COMPLETED: July 1, 1974

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes x No
If so, how ___

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Potts Drilling and Developing 150
Driller's or Firm Name *License No.*

Route #4. Box 96 Bozeman, Montana
Address

Aug. 6, 1974
Signed by

55045

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the we

1. WELL OWNER
Name EXXON USA

2. CURRENT MAILING ADDRESS
PO Box 30537
BILLINGS MT 59107

3. WELL LOCATION
County GALLATIN
Township 2 N Range 6 W
NW ¼ NW ¼ NW ¼ Section 6
Lot Block
Subdivision

4. PROPOSED USE Domestic Stock Irrigation X
Other specify

5. DRILLING METHOD cable, bored,
X forward rotary, reverse rotary, jetted,
other (specify)

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations and/or Screens Kind Size	From (feet)	To (feet)
6"	6" 18#/FT	0	60			

Was casing left open end? X Yes No
Was a packer or seal used? Yes X No
If so, what material
Was the well gravel packed? Yes X No
Was the well grouted? Yes X No
To what depth?
Material used in grouting CHAG
Well head completion: Pitless adapter
X Yes No
Top of casing 12 in. or greater above grade
X Yes No

7. WHAT IS THE TEMPERATURE OF THE WATER?
50 Degrees Fahrenheit
Measured X Estimated

8. WATER LEVEL
Static water level 8 feet below land surface
If flowing, closed-in pressure
gpm
Controlled by valve, reduc
other (specify)

9. WELL TEST DATA X pump bailer
other, (specify)
Pumping water level below land surface:
52 ft. after 2 hrs pumping 20 gpm
ft. after hrs pumping

10. WAS WELL PLUGGED OR ABANDONED? Yes X
If yes, how?

11. DATE COMPLETED 9-2-85

12. WELL LOG

Depth (ft.) From	To	Formation
0	2	Top soil
2	5	CLAY
5	60	clay & gravel mix

RECEIVED
JAN 11 1984
MONTANA D.N.R.C.
BOZEMAN FIELD OFFICE

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
11-9-85
Date
Hassett Drilling
Firm Name
2240 Texas Way Bozeman
Address
Ken Hassett 353
Signature License No

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59620 449-3962

DEPARTMENT COPY

State Publishing Co. Helena, Mont.

DRILL ... this copy to the well owner to consider ...

OWNER: Complete a new copy of Form 602 and send to ...

49720

File No

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well

1 WELL OWNER
Name Paul Carter

2 CURRENT MAILING ADDRESS
1011 E. Griffin Dr.
Bozeman, Mont. 59715

3. WELL LOCATION
County Gallatin
Township 1S N/S Range 6E E/W
SE ¼ SE ¼ SE ¼ Section 31
Lot Block
Subdivision

4 PROPOSED USE Domestic Stock X Irrigation
Other specify

5. DRILLING METHOD X cable. bored.
forward rotary. reverse rotary. jetted.
other (specify)

6 WELL CONSTRUCTION AND COMPLETION

Size of drill hole	Size and weight of casing	From (feet)	To (feet)	Perforations Screen Kind Size	From (feet)	To (feet)
6"	6" 19#	0	75'2"			

Was casing left open end? X Yes No
Was a packer or seal used? X Yes No
If so, what material drill cuttings
Was the well gravel packed? Yes X No
Was the well grouted? Yes X No
To what depth?
Material used in grouting
Well head completion Pitless adapter
X Yes No
Top of casing 12 in. or greater above grade
X Yes No

7 WHAT IS THE TEMPERATURE OF THE WATER?
50 Degrees Fahrenheit
Measured X Estimated

8 WATER LEVEL
Static water level 30 feet below land surface
If flowing, closed-in pressure psi
gpm
Controlled by: valve. reducers
other. (specify)

9. WELL TEST DATA pump X bailer
other. (specify)
Pumping level below land surface:
67 ft. after 1 hrs. pumping 16 gpm
ft. after hrs. pumping gpm

10 WAS WELL PLUGGED OR ABANDONED? Yes X No
If yes, how?

11. DATE COMPLETED 3/14/83

12. WELL LOG

Depth (ft.) From	To	Formation
0	6	top soil
6	41	gravel - clayhound
41	45	sand & gravel
45	51	sand & gravel tight formation
51	53	sand & gravel some water
53	63	sandy clay - wet
63	74	clayhound gravel - dry
74	77	sand & gravel - water

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
3/21/83
Date
VanDyken Drilling
Firm Name
417 N. 6th Bozeman, Mont. 59715
Address
306
Signature License No

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59620 449-3962

DEPARTMENT COPY
[illegible] to the well owner to complete reverse side.
[illegible] Form 602 and send to DNRC

RECEIVED

JUL 1984

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION

File No 57103.

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well

1 WELL OWNER
Name Houser Const

2. CURRENT MAILING ADDRESS
304 S Church
Bozeman, MT 59715

3. WELL LOCATION
County Gallatin
Township 1 N/S Range 6 E/W
SE ¼ NE ¼ SE ¼ Section 31
Lot Tract C Block
Subdivision Farmers

4. PROPOSED USE Domestic X Stock Irrigation
Other specify

5 DRILLING METHOD cable, bored,
X forward rotary, reverse rotary, jetted,
other (specify)

6 WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations / Screen	From (feet)	To (feet)
6"	6" 17# A+	0	91			

Was casing left open end? X Yes No
Was a packer or seal used? Yes X No
If so, what material
Was the well gravel packed? Yes X No
Was the well grouted? Yes X No
To what depth?
Material used in grouting drill mud
Well head completion: Pitless adapter
X Yes No
Top of casing 12 in. or greater above grade
X Yes No

7. WHAT IS THE TEMPERATURE OF THE WATER?
50 Degrees Fahrenheit
Measured X Estimated

8. WATER LEVEL
Static water level 7 feet below land surface
If flowing: closed-in pressure psi
gpm
Controlled by: valve, reducers,
other, (specify)

9. WELL TEST DATA X pump baller
other, (specify)
Pumping water level below land surface:
50 ft. after 2 hrs. pumping 35 gpm
ft. after hrs. pumping gpm

10. WAS WELL PLUGGED OR ABANDONED? Yes X No
If yes, how?

11. DATE COMPLETED 7-6-84

12. WELL LOG

Depth (ft.) From	To	Formation
0	28	Gravel
28	95	Gravel & clay mix

RECEIVED
JUL 27 1984
MONTANA D.N.R.C.
BOZEMAN FIELD OFFICE

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
7-23-84 Date
Hoggett Drilling Firm Name
2810 Texas Way Bozeman Address
Signature 353 License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59620 449-3962

DEPARTMENT COPY

DRILLER: Please give this copy to the well owner to complete reverse side.

OWNER: Complete reverse side of Form 602 and send to DNRC.

Form No. 97-J (R 6-84)

RECEIVED

JUN 06 1986

MONT. DEPT. of NATURAL RESOURCES & CONSERVATION

File No. 61531 G4LH

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. **WELL OWNER**
Name Spring Hill Corporation

2. **CURRENT MAILING ADDRESS**
2504 West Main Suite L
Bozeman, Montana 59715

3. **WELL LOCATION**
County Gallatin
Township 1 N S Range 6 E W
SW ¼ SW ¼ NW ¼ Section 31
Lot _____ Block _____
Subdivision _____

4. **PROPOSED USE** Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ specify _____

5. **DRILLING METHOD** _____ cable, _____ bored,
X rotary, _____ reverse rotary, _____ jetted,
_____ other (specify) _____

6. **WELL CONSTRUCTION AND COMPLETION**

Size of casing (in.)	Type and weight of casing	Depth (feet) From	Depth (feet) To	Perforations Screens (Kind) Slots	From (feet)	To (feet)
6"	6 17 lbs/ft	0	40			

Was casing left open end? ____ Yes X No
Was a packer or seal used? ____ Yes X No
If so, what material
Was the well gravel packed? ____ Yes X No
Was the well grouted? ____ Yes X No
To what depth?
Material used in grouting
Well head completion: Pitless adapter
X Yes ____ No
Top of casing 12 in. or greater above grade
X Yes ____ No

7. **WHAT IS THE TEMPERATURE OF THE WATER?**
_____ Degrees Fahrenheit
☐ Measured ☐ Estimated

8. **WATER LEVEL**
Static water level 5 feet below land surface
If flowing; closed-in pressure _____ psi
_____ gpm
Controlled by: _____ valve, _____ reducers,
_____ other, (specify) _____

9. **WELL TEST DATA** _____ pump _____ bailer
X other, (specify) air
Pumping water level below land surface:
40 ft. after 1 hrs. pumping 50 gpm
_____ ft. after _____ hrs. pumping _____ gpm

10. **WAS WELL PLUGGED OR ABANDONED?** ____ Yes X No
If yes, how? _____

11. **DATE COMPLETED** 12/9/85

12. **WELL LOG**

Depth (ft.) From	To	Formation
0	20	sand, gravel + clay
20	40	sand + gravel

(use separate sheet if necessary)

13. **DRILLER'S CERTIFICATION**
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
12/9/85
Date
Hillman Drilling
Firm Name
RT 85 Box 4286 Livingston, MT 59047
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59620 444-6610

DEPARTMENT COPY

65383

CORRECTED

WELL LOG REPORT

[illegible] the water well driller within 60 days after completion [illegible]

1 WELL OWNER
Name MARCIA E. ANDERSON

2 CURRENT MAILING ADDRESS
8420 BRIDGER CANYON DR.
BOZEMAN MT 59715

3. WELL LOCATION
County GALLATIN
Township 1 N (S) Range 6 (E) W
SE ¼ [illegible] ¼ [illegible] ¼ Section 31
Lot 1 Block 1
Subdivision BRIDGER CENTER
See Exhibit A for complete description.

4. PROPOSED USE Domest. X Stock Irrigation
Other ☐ specify

5. DRILLING METHOD X cable, bored,
forward rotary, reverse rotary, jetted,
other (specify)

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)
6 5/8	19lb.	0	36

Perforations and/or Screen

Kind Size	From (feet)	To (feet)

Was casing left open end? X Yes No
Was a packer or seal used? Yes X No
If so, what material
Was the well gravel packed? Yes X No
Was the well grouted? X Yes No
To what depth? 20 ft.
Material used in grouting CONCRETE
Well head completion: Pitless adapter
Y Yes No
Top of casing 12 in. or greater above grade
X Yes No

7. WHAT IS THE TEMPERATURE OF THE WATER?
48 Degrees Fahrenheit
☐ Measured X Estimated

8 WATER LEVEL
Static water level 5 feet below [illegible]
Flowing pressure [illegible]
[illegible] gpm
Controlled by valve
other specify

9. WELL TEST DATA [illegible] pump [illegible]
other (specify)
Pumping water level below land surface
8 ft. after [illegible] hrs pumping [illegible]
ft. after hrs pumping

10. WAS WELL PLUGGED OR ABANDONED? yes
If yes, how?

11. DATE COMPLETED 4 - 5 - 86

12. WELL LOG

Depth (ft.) From	To	Formation
1	4	FILL GRAVEL
4	11	GRAVEL & ROCK
11	17	MUD & SAND
17	23	GRAVEL
23	31	CLAY
31	36	SMALL GRAVEL

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
4-5-86
Date
MAHURIN EXC. & DRILLING
Firm Name
Box 2013 BOZEMAN MT. 59715
Address
[signature]
Signature
359
License No

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59620 449-3962

DEPARTMENT COPY

DRILLER: Please give this copy to the well owner to complete reverse

OWNER: Complete reverse side of Form 602 and send to DNRC

RECEIVED
JUL .. 1975

[illegible] Department of Natural Resources and Conservation

WELL LOG REPORT 9457 [illegible] 59715

[illegible] ... this form to be filed by the water well driller on any ... within sixty (60) days after completion of the ...

Name Gallatin [illegible] Society Address Bozeman, Montana [illegible]

WELL LOCATION: County Gallatin ; S½ ¼ ¼, Sec. 31, Twp. 1 N-(S), Rg. 6 [illegible]

PROPOSED USE: ___ Domestic ___ Stock X Municipal ___ Industrial ___ Lawn and Garden ___ Irrigation ___ Other (if other, specify) ___

METHOD DRILLED: X Cable ___ Bored ___ Forward Rotary ___ Reverse Rotary ___ Jetted ___ Other (if other, specify)

WELL CONSTRUCTION:
Diameter of hole 6 inches. Depth 40 ft.
Casing: X Steel ___ Plastic ___ Concrete
___ Threaded X Welded ___ Other (if other, specify)

Pipe Weight/Dia.: From: To:
17 lb/ft. 6 inches 1 above feet 40½ feet
___ lb/ft. ___ inches ___ feet ___ feet
___ lb/ft. ___ inches ___ feet ___ feet

Was perforated pipe used? ___ Yes X No
Length of pipe perforated ___ feet
Was casing left open end? X Yes ___ No
Was a well screen installed? ___ Yes X No
Material ___ Dia. ___ inches
(stainless steel, bronze, etc.)
Perforation type: ___ slots ___ holes
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Was a packer or seal used? ___ Yes ___ No
If so, what material
Well type: ___ Straight screen ___ Graveled
Was the well grouted? X Yes ___ No
To what depth? 20 feet
Material used in grouting Clay grout
Well head completion: Pitless adapter
12" above grade ___, Other
(if other, specify)
Was the well disinfected? ___ Yes X No

WATER LEVEL:
Static water level 6 ft. below land surface
If flowing: closed-in pressure ___ psi
GPM flow ___ through ___ inch pipe
Controlled by: ___ Valve ___ Reducers
___ Other, specify

WELL TEST DATA: Pump X Bailer ___ Other
(if other, specify)
Pumping level below land surface:
12 ft. after 1 hrs. pumping 20 gpm
___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG:

Depth (ft.) From	To	Formation
0	5	soil and rock
5	10	gravel
10	15	gravel & rock
15	20	gravel & clay
20	25	gravel, lots of sand & water
25	30	gravel water and fine sand
30	35	gravel & water
35	37	clay & rock
37	41	clay sand & water

(Use separate sheet if necessary)

9. DATE STARTED: June 26 1975

10. DATE COMPLETED: June 28 1975

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes ___ No
If so, how

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Hulbert Drilling 47
Driller's or Firm Name License No.

Route one Bozeman, Montana
Address

June 30 1975
Signed by Date
[illegible] Hulbert

Form No. 603R2 5/1

FOR NO 46736

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER Name: Wm. Sievers

2. CURRENT MAILING ADDRESS: 324 W. Main, Bozeman, MT. 59715

3. WELL LOCATION
County: Gallatin
Township 1 N (S) Range 6 (E) W
¼ SW¼ SW¼ Section 31
Lot Tract 10 Block
Subdivision

4. PROPOSED USE: Domestic ☐ Stock ☐ Irrigation ☐
Other (specify): Industry

5. DRILLING METHOD: X cable, ____ bored, ____ forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify)

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations / Screen Kind	Size	From (feet)	To (feet)
6"	6" 19#	0	58				

Was casing left open end? X Yes ____ No
Was a packer or seal used? X Yes ____ No
If so, what material: drill cuttings
Was the well gravel packed? ____ Yes X No
Was the well grouted? ____ Yes X No
To what depth?
Material used in grouting
Well head completion: Pitless adapter ____ Yes ____ No
Top of casing 12 in. or greater above grade X Yes ____ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
50 Degrees Fahrenheit ☐ Measured X Estimated

8. WATER LEVEL
Static water level 6 feet below land surface
If flowing: closed-in pressure ____ psi
____ gpm
Controlled by: ____ valve, ____ reducers, ____ other, (specify)

9. WELL TEST DATA ____ pump X bailer ____ other, (specify)
Pumping level below land surface:
50 ft. after 1 hrs. pumping 12 gpm
____ ft. after ____ hrs. pumping ____ gpm

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes X No
If yes, how?

11. DATE COMPLETED 11-9-81

12. WELL LOG

Depth (ft.) From	To	Formation
0	3	Top soil
3	11	Gravel
11	19	Clay
19	36	clay & gravel
36	38	Gravel w/ trace water
38	55	clay & gravel
55	58	gravel

(use reverse sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge. Date 11/23/81
Van Dyken Drilling
Firm Name
417 N. 6th Bozeman, Mt. 59715
Address
Mike Jensen Andersen 306
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION **DNRC**
32 SOUTH EWING HELENA, MONTANA 59620 449-3962

DEPARTMENT COPY
DRILLER Please give this copy to the well owner to complete reverse side.
OWNER Complete reverse side Form 602 and send to DNRC.

25062

Hallie Lughimer   1410 Story Mill Rd
Bozeman, Mt. 59715

WELL TEST DATA ___ pump X bailer ___ other

Pumping water level below land surface

___ ft. after 2 hrs. pumping ___ gpm

___ ft. after ___ hrs. pumping ___ gpm

9. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No

If yes, how? ___

10. DATE STARTED ___

DATE COMPLETED 2/21/79

11. WELL LOG

Depth (ft.) From	To	Formation
0	2	top soil
2	8	clay bound gravel
8	23	wet clay bound gravel
23	30	dry clay bound sand & gravel
30	41	clay bound sand
41	46	sand & gravel - water
46	61	clay bound gravel
61	63	gravel

___ NW ¼ Section 32

T. 1S N or S R 6E E or W

OR, Lot ___ Block ___

Subdivision ___

City ___ County Gallatin

Elevation ___ Accuracy ___ ±10' ___ ±50' ___ ±100'

5. DRILLING METHOD ___ cable, ___ bored, ___ forward rotary, ___ reverse rotary ___ jetted, ___ other (specify) ___

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations ___ and/or Screen ___ Kind Size	From (feet)	To (feet)
6"	6" 19lbs	0	63			

Was casing left open end? X Yes, ___ No

Was a packer or seal used? X Yes, ___ No

If so, what material drill cuttings

Was the well gravel packed? ___ Yes, X No

Was the well grouted? ___ Yes X No

To what depth? ___

Material used in grouting ___

Well head completion: Pitless adapter X ___

12 in. above grade ___ other ___

If other, specify ___

Pump horsepower ___ Pump type ___

Pump intake level ___ ft below land surface

Power: electric, diesel, etc. ___

12. DRILLER'S CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

___ Date

[illegible] Drilling

Firm Name

23714

RECEIVED

WELL LOG REPORT

MONT DEPT OF NATURAL RESOURCES & CONSERVATION

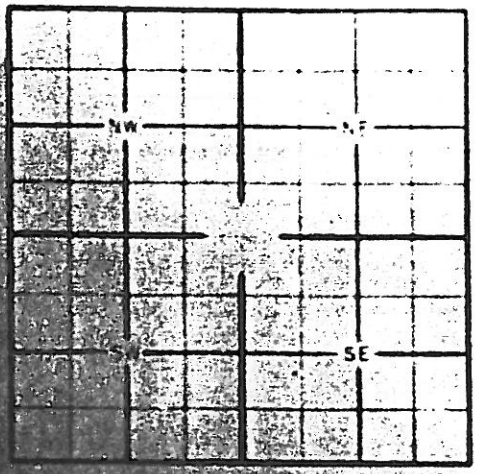
White Department
Yellow Department
Pink-Well Owner
Gold-Driller

1. WELL OWNER
Name [illegible] SWINGLE

2. CURRENT MAILING ADDRESS
1204 STORY MILL Rd
BOZEMAN MT 59715

3. PROPOSED USE
_____ domestic (includes lawn and garden), _____ stock, _____ municipal, _____ industrial,
_____ irrigation, _____ other (specify)

4. WELL LOCATION



¼ ¼ ¼ ¼ Section 32
T. _____ R. 6E
N or S E or W
DA Lot _____ Block _____
Subdivision _____
City _____ County Gallatin
Elevation _____ Accuracy: ±10'; ±50'; ±100';

5. DRILLING METHOD
_____ cable, _____ bored,
_____ forward rotary, _____ reverse rotary, ___ jetted,
_____ other (specify)

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole (inches)	Static water level (feet)	Pumping water level (feet)	Depth (feet)	Perforations _____ and/or Screen _____ Kind & Size	From (feet)	To (feet)
5 7/8			72			

Was casing left in well? _____ Yes, _____ No
Was casing welded? _____ Yes, _____ No
If welded, how?
Was the well gravel packed? _____ Yes, X No
Was the well grouted? _____ Yes, X No
If yes, depth?
Material used in grouting _____
Well completion: Pitless adapter Yes
_____ ft. above grade _____, other 1'
(If other, specify) _____
Pump horsepower ½ hp, pump type submersible
Pump intake level _____ feet below land surface
Power (electric, diesel, etc.) _____

7. WELL TEST DATA X pump _____ bailer _____ other
(if other, specify) _____
Pumping level below land surface:
_____ ft. after ½ hrs. pumping 20 gpm
_____ ft. after _____ hrs. pumping _____ gpm

8. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If yes, how? _____

9. DATE STARTED March 27, 1979
DATE COMPLETED March 28, 1979

10. WELL LOG
Depth (ft.)

From	To	Formation
0	10	Top Soil
10	30	Gravel
30	43	Clay
43	48	Sand & Gravel with Clay
48	60	Gravel
60	65	Clay
65	72	Cemented Gravel

(use separate sheet if necessary)

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
6/20/79
Date
Jones Welding & Irrigation Company
Firm Name

46730

...servation

REPORT

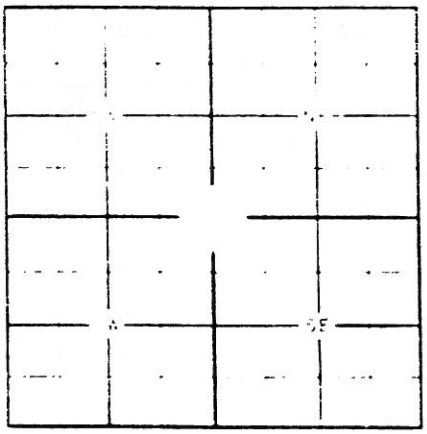
...Dep...
Yellow Department
Pink Well Owner
Gold-Driller

1. WELL OWNER
Name Calvert Jacobson

2. CURRENT MAILING ADDRESS
1925 Bridger Drive
Bozeman, Montana

3. PROPOSED USE ___X___ domestic (includes lawn and garden); _____ stock; _____ municipal; _____ industrial
_____ irrigation _____ other (specify)

4. WELL LOCATION



___ ¼ NW ¼ SW ¼ SE ¼ Section 32
T. 1 S N or S R. 6 E E or W
OR, Lot _____ Block _____
Subdivision Ed Vogel Sub division #1
City _____ County Gallatin
Elevation _____ Accuracy: ___ ±10'; ___ ±50'; ___ ±100'

5. DRILLING METHOD ___X___ cable, _____ bored,
_____ forward rotary, _____ reverse rotary, _____ jetted,
_____ other (specify) _____

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations _____ and/or Screen _____ Kind Size	From (feet)	To (feet)
6"	6 5/8 OD x 17#	+1	34			

Was casing left open end? ___X___ Yes, _____ No
Was a packer or seal used? _____ Yes, ___X___ No
If so, what material _____
Was the well gravel packed? _____ Yes, ___X___ No
Was the well grouted? _____ Yes, ___X___ No
To what depth? _____
Material used in grouting _____
Well head completion: Pitless adapter yes
12 in. above grade ___X___, other _____
(if other, specify) _____
Pump horsepower ½, pump type Submersible
Pump intake level _____ feet below land surface
Power (electric, diesel, etc.) _____

7. WATER LEVEL
Static water level 14½ feet below land surface
If flowing, closed in pressure _____ psi
_____ gpm flow through _____ inch pipe
Controlled by ___ valve, ___ reducers ___ other

8. WELL TEST DATA _____ pump ___X___ bailer _____ other
(if other, specify) _____
Pumping level below land surface:
54 ft. after 1 hrs. pumping 25 gpm
___ ft. after ___ hrs. pumping ___ gpm

9. WAS WELL PLUGGED OR ABANDONED? ___ Yes ___X___ No
If yes, how? _____

10. DATE STARTED Sept. 29, 1958
DATE COMPLETED Oct. 4, 1958

11. WELL LOG
Depth (ft.)

From	To	Formation
0	5	Top Soil & Clay
5	26	Coarse Gravel
26	32	Clay
32	35	Fine Gravel

(use separate sheet if necessary)

12. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

_____ Date

Jones Welding & Drilling Co.
Firm Name

2107 Bridger Drive - Bozeman, Montana
Address

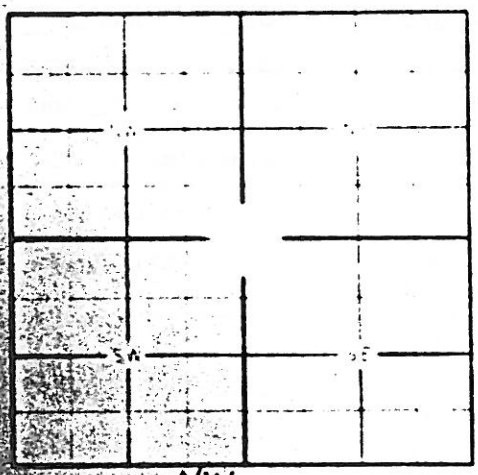
21416

1 WELL OWNER
Name DAN WESSEN

2 CURRENT MAILING ADDRESS
ROUTE #2 BOX 298 BOZEMAN, MT

3. PROPOSED USE
X domestic (includes lawn and garden) ____ stock ____ municipal ____ industrial
____ irrigation ____ other (specify)

4. WELL LOCATION



NW ¼ SE ¼ Section 26
T. 15 N or S R. 5E E or W
OR: Lot ____ Block ____
Subdivision ____
City ____ County Gallatin
Elevation ____ Accuracy: ___ ±10'; ___ ±50'; ___ ±100';

5. DRILLING METHOD
X cable, ____ bored,
____ forward rotary, ____ reverse rotary, ____ jetted,
____ other (specify)

6. WELL CONSTRUCTION AND COMPLETION

Size of hole diameter	Size and weight of casing	From (feet)	To (feet)	Perforations ____ and/or Screen ____ Kind	Size	From (feet)	To (feet)
6"	6" 17#	+1	68				

Was casing left open end? X Yes, ____ No
Was a packer or seal used? ____ Yes, X No
If so, what material ____
Was the well gravel packed? ____ Yes, X No
Was the well grouted? ____ Yes, X No
To what depth? ____
Material used in grouting ____
Well head completion: Pitless adapter X
12 in. above grade ____, other ____
(if other, specify) ____
Pump horsepower 1 pump type Sc B
Pump intake level 60 feet below land surface
Power (electric, diesel, etc.) ____

7. WATER LEVEL
Static water level 4'2" XXX feet below land surface
If flowing, closed-in pressure ____ psi
____ gpm flow through ____ inch pipe

8. WELL TEST DATA ____ pump X bailer ____ other
(if other, specify) ____
Pumping level below land surface:
292 ft. after 1 hrs. pumping 45 gpm
____ ft. after ____ hrs. pumping ____ gpm

9. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If yes, how? ____

10. DATE STARTED July 14, 1978
DATE COMPLETED July 18, 1978

11. WELL LOG
Depth (ft.)

From	To	Formation
0	3	clay
3	25	dirty sandstone
25	66	clay, some sand and gravels
66	68	sand and gravel

(use separate sheet if necessary)

12. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
July 25, 1978
Date
Potts Drilling and Developing
Firm Name
Route #4, Box 96 Bozeman, Montana
Address
[signature]

150

RECEIVED

MAY 09 1983

Form No. 603 R2'81

File No. 53029

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well

1. WELL OWNER
Name Tom Kuinar

2. CURRENT MAILING ADDRESS
103 No. Western Drive
Bozeman, Montana

3. WELL LOCATION
County Gallatin
Township 1S N/S Range 5E E/W
¼ ¼ E ¼ Section 35
Lot 4 Block Tract C
Subdivision Gardner Sementhal Sub.

4. PROPOSED USE Domestic ☒ Stock ☐ Irrigation ☐
Other ☐ (specify)

5. DRILLING METHOD ___ air, ___ cable, ___ bored,
___ diamond rotary, ___ reverse rotary, ___ jetted,
___ other (specify)

6. WELL CONSTRUCTION AND COMPLETION

Kind of material	Size of casing	From (feet)	To (feet)	Perforations	From (feet)	To (feet)
6"	6"	17	45			
		75				

Was casing left open inside? X Yes ___ No
Was a packer or seal used? ___ Yes X No
If so, what material?
Was the well gravel packed? ___ Yes X No
Was the well grouted? ___ Yes X No
To what depth?
Material used in grouting
Well head completion: Pitless adapter
X Yes ___ No
Top of casing 12 in. or greater above grade
___ Yes X No

7. WHAT IS THE TEMPERATURE OF THE WATER?
___ Degrees Fahrenheit
☐ Measured ☐ Estimated

8. WATER LEVEL
Static water level XXXXXXXXXX 6 feet below land surface
If flowing: closed-in pressure ___ psi
___ gpm
Controlled by: ___ valve, ___ reducers,
___ other, (specify)

9. WELL TEST DATA X pump ___ bailer
___ other, (specify)
Pumping level below land surface:
31 ft. after 1 hrs. pumping 25 gpm
___ ft. after ___ hrs. pumping ___ gpm

10. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If yes, how?

11. DATE COMPLETED May 2,1983

12. WELL LOG

Depth (ft.) From	To	Formation
0	7	topsoils
7	20	clay,rock & gravel overburden
20	23	loose rock,gravel
23	43	tight,dirty gravels
43	45	sand and gravel

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

May 5,1983
Date

Potts Drilling and Developing
Firm Name

80730 Gallatin Road Bozeman, Montana
Address

Richard Potts 150
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59620 449-3962

DEPARTMENT COPY
DRILLER Please give this copy to the well owner to complete reverse side
OWNER Complete reverse side Form 602 and send to DNRC

39746

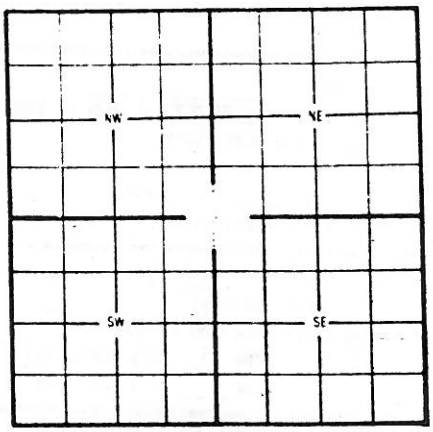
WELL LOG REPORT

Mail this form to the water well driller within 60 days after completion of the well.

1. WELL OWNER Montana Corporation
Name c/o U.P.S.

2. CURRENT MAILING ADDRESS
3 North 35 St.
Billings, Montana 59101

3. WELL LOCATION



¼ ¼ E ¼ Section 35
Township 1 S N/S Range 5 E E/W
County Gallatin
Lot 3 & 4 Tract 7
Subdivision Gardner Sementhal Plaza
Well Elevation
Accuracy: ± 10'; ± 50'; ± 100';

4. DRILLING METHOD x cable, bored, forward rotary, reverse rotary, jetted, other (specify)

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations and/or Screen		
				Kind Size	From (feet)	To (feet)
6"	6" 17#	+2'5"	83' 5½"			

Was casing left open end? x Yes No
Was a packer or seal used? Yes x No
If so, what material
Was the well gravel packed? Yes x No
Was the well grouted? Yes x No
To what depth?
Material used in grouting
Well head completion: Pitless adapter
12 in. above grade – , or other
(if other, specify)
Pump horsepower , pump type
Pump intake level feet below land surface
Power (electric, diesel, etc.)

6. WATER LEVEL
Static water level 4½ feet below land surface
If flowing, closed-in pressure psi
gpm flow through inch pipe
Controlled by: valve, reducers, other
(if other, specify)

7. WELL TEST DATA pump x bailer other
(if other, specify)
Pumping level below land surface:
35 ft. after 2 hrs. pumping 30 gpm
ft. after hrs. pumping gpm

8. WAS WELL PLUGGED OR ABANDONED? Yes x No
If yes, how?

9. DATE STARTED ,81
DATE COMPLETED ,81

10. WELL LOG

Depth (ft.) From	To	Formation
0	8	topsoils and rock
8	22	loose rock and gravel
22	43	dry, loose gravels
43	47	sands and gravels
47	57	fine sands
57	84	coarse sands and gravels

RECEIVED
DEC 22 1981
MONTANA D.N.R.C.
BOZEMAN FIELD OFFICE

(use separate sheet if necessary)

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
October 30, 1981
Date
Potts Drilling and Developing
Firm Name
80730 Gallatin Rd. Bozeman, Montana 59715
Address
Signature
150
License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59601 449-3634

File No. 16755-9HH

STATE OF MONTANA
Department of Natural Resources and Conservation

White-Department
Pink-Bureau
Yellow-Well owner
Gold-Driller

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of (1) any water well, and form 606, Notice of Completion of Groundwater Development, be filed by the well owner within 60 days after the water has been put to beneficial use.

1. WELL OWNER Current address 1121 Vanderille Lane - Bozeman, Montana

2. WELL LOCATION Lot ____, Block ____, Subdivision ____
County Gallatin, or SW ¼ SW ¼ NE ¼ Sec. 24, T. 1 N, R. 5 E

3. PROPOSED USE: X domestic (includes lawn and garden); ____ stock; ____ municipal; ____ industrial; ____ irrigation; ____ other (specify) ____

4. METHOD DRILLED: X cable, ____ bored, ____ jetted, ____ driven, ____ dug, ____ air rotary, ____ reverse rotary, ____ other (specify) ____

5. WELL CONSTRUCTION
Diameter of hole 6 in., depth 325 ft.
Casing: X steel, ____ plastic, ____ concrete, ____ threaded, X welded, ____ other (specify)

Pipe weight:
____ lb/ft. Diam. 6 in. From 2 ft. To 174 ft.
____ lb/ft. Diam. ____ in. From ____ ft. To ____ ft.
Was casing left open during drilling? ____ Yes X No
Was a well screen installed? X Yes ____ No
Material: Stainless Steel dia. 6 in.
(stainless steel, brass, etc.)
Was perforated pipe used? ____ Yes XX No
Perforation type: ____ holes
Size ____ set from ____ ft. to ____ ft.
Size ____ set from ____ ft. to ____ ft.
Was packer or seal used? X Yes ____ No
If so, what material? Lead
Well type: X Straight screen ____ Graveled
Was the well grouted? ____ Yes X No
To what depth? ____ ft.
Interval used in grouting ____
Well head completion: Pitless adapter ____
12 in. above grade ____, other ____
(if other, specify)
Was well disinfected? ____ Yes X No

6. WATER LEVEL
Static water level ____ ft. below land surface
If flowing, closed-in pressure ____ psi
gpm flow ____ through ____ inch pipe
Controlled by: ____ valve ____ reducers
other (specify) ____

7. WELL TEST DATA X Pump ____ Bailer ____ Other
(if other, specify)
Pumping level below land surface:
____ ft. after ____ hrs. pumping 45 gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WELL LOG

Depth (ft) From	To	Formation
0	19	Clay
19	36	Gravel
36	49	Gravel bound in Clay
49	76	Sand & Gravel with Clay
76	95	Sand & Clay
95	120	Sand & Fine Gravel & Clay
120	125	Sand & Fine Gravel
125	135	Sand & Gravel bound in Clay
135	155	Clay
155	165	Sand & Fine Gravel
165	175	Sand & Gravel bound in Clay
175	180	Clay
180	190	Sand
190	195	Sand & Fine Gravel with Clay
195	205	Sand & Gravel bound in Clay
205	282	Clay
282	285	Sand
285	288	Sand & Fine Gravel
288	289	Sand & Gravel bound in Clay
289	300	Clay
300	301	Sand & Fine Gravel
301	304	Sand & Fine Gravel bound in Clay
304	316	Clay
316	317	Sand & Fine Gravel
317	319	Sand & Fine Gravel with Clay
319	325	Sand & Fine Gravel bound in Clay
		Clay

(use separate sheet if necessary)

9. DATE STARTED March 16, 1976
DATE COMPLETED May 12, 1976

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes X No
If so, how? ____

11. DRILLER'S CERTIFICATION
This well was drilled under my supervision and this report is true to the best of my knowledge.

Jones Welding & Drilling Co. 17
Driller's or firm name License No.

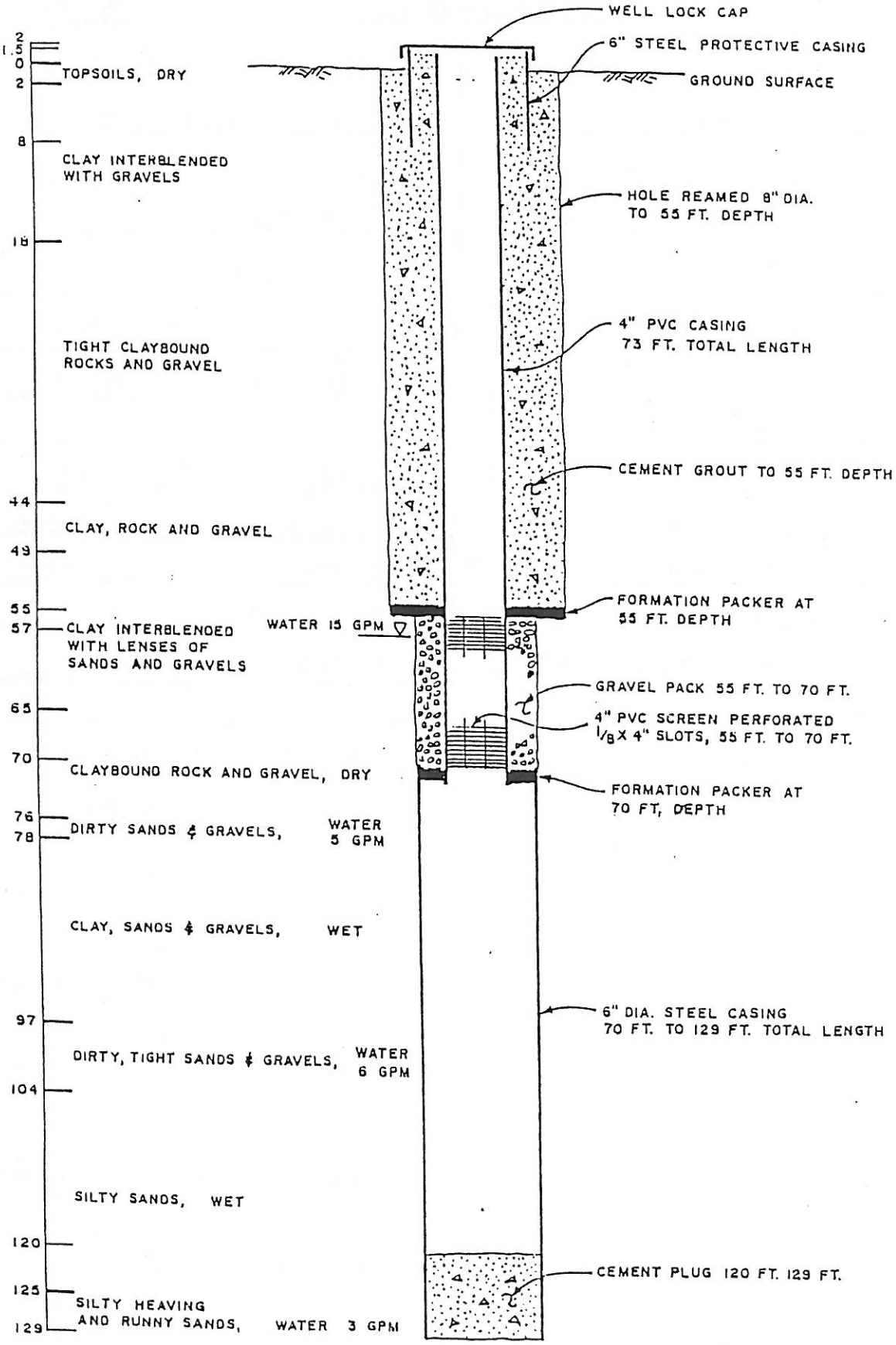
2103 Bridger Drive - Bozeman, Montana
Address

Milton E. Jones 12/10/77
Signed by date

APPENDIX D

LANDFILL MONITORING AND SHOP WELL LOG REPORTS

CITY OF BOZEMAN SANITARY LANDFILL MONITORING #1 NORTH WELL



ROUTE ONE
BOZEMAN, MONTANA

POTTS DRILLING CO.

TELEPHONE
586-6812

Name City of Bozeman
Street Sanitary Landfill
Town Monitoring Well #1
Location North Boundy Well
1/4 1/4 Sec. Twp Rng

Start 11-11-80 Finish 11-21-80
Size 4" Weight PVC
Driller Herb
Rig 71 Star

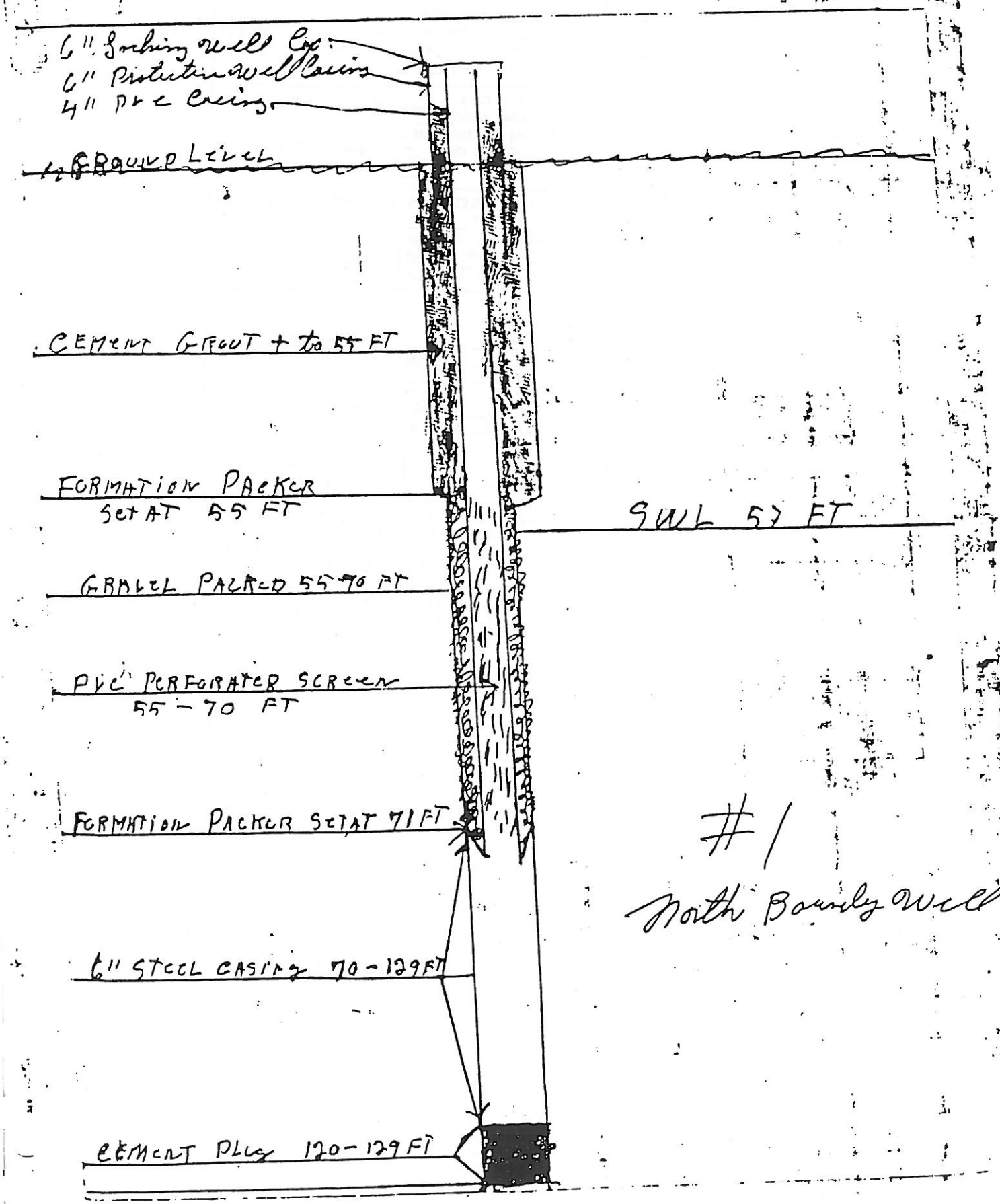
From / To	Formation	Water
0 / 2	topsoils	dry
2 / 18	clay interblended with gravels	
18 / 44	tight claybound rocks and gravel	
44 / 49	clay, rock & Gravel	
49 / 65	clay interblended with lenses of sands and gravels	water 15 gpm
65 / 76	claybound rock	dry and gravel
76 / 78	dirty sands & gravels	dry -water
78 / 97	clay, sands & gravels	5 gpm wet
97 / 104	dirty, tight sands and gravels	water
104 / 125	silty sands	6 gpm wet
125 / 129	silty heaving, runny sands	water 3 gpm.

CASING LOG

#	Length	Total
	water samples	
#1	11-12-80	49-65'
	temp. 12° C.	
	Conducitivity	260
	yield	15 gpm.
#2	11-13-80	76-78 ft.
	temp. 10° C.	
	Conducitivity	280
	total drilling	129 ft.
	total casing	(4"pvc) 73'
	total casing	6" steel
		70-129' +2'-8'
4"	pvc casing	+1'6" to 72ft.
	set at 71 ft.	
4X7	formation packer set at	
		55 ft.
	cement grouted to 45 ft.	
	S.W.L.	57 ft.
	amount	15 gpm
#3	11-17-80	97-104'
	temp. [redacted] C	
	Conducitivity	240 [redacted]
	Yield	2 gpm.

Remarks: 4" pvc casing perforated ½X 4" slots 49-70'

City of Bozeman Sanitary Landfill Monitoring Well #1



Form No. 603 R10/79 77

File No. _____

1

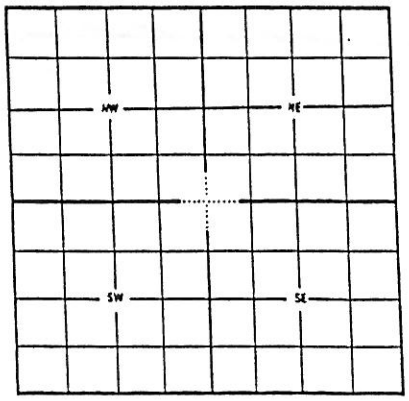
WELL LOG REPORT

State law requires that this form be filled by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name City of Bozeman

2. CURRENT MAILING ADDRESS
Sanitary Landfill
Bozeman, Montana

3. WELL LOCATION



____¼ ____¼ ____¼ Section _____
Township _____ N/S Range _____ E/W
County Gallatin
Lot _____ Block _____
Subdivision _____
Well Elevation _____
Accuracy: ____ ±10'; ____ ±50'; ____ ±100';

4. DRILLING METHOD x cable, ____ bored, ____ forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) _____

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations x and/or Screen		
				Kind Size	From (feet)	To (feet)
4"	pvc	+1½	72			
6"	steel		129	Slots ⅛X4'	49	70

Was casing left open end? ____ Yes x No
Was a packer or seal used? x Yes ____ No
If so, what material 4X7 formation packer
Was the well gravel packed? x Yes ____ No
Was the well grouted? x Yes ____ No
To what depth? 45
Material used in grouting cement
Well head completion: Pitless adapter _____
12 in. above grade _____, other _____
(If other, specify) _____
Pump horsepower _____, pump type _____
Pump intake level _____ feet below land surface
Power (electric, diesel, etc.) _____

6. WATER LEVEL
Static water level 57 feet below land surface
If flowing, closed-in pressure _____ psi
_____ gpm flow through _____ inch pipe
Controlled by: _____ valve, _____ reducers, _____ other
(If other, specify) _____

7. WELL TEST DATA x pump x bailer air other
(If other, specify) _____
Pumping level below land surface:
65 ft. after 5 hrs. pumping 15 gpm
_____ ft. after _____ hrs. pumping _____ gpm

8. WAS WELL PLUGGED OR ABANDONED? ___ Yes x No
If yes, how? _____

9. DATE STARTED 11-11-80
DATE COMPLETED 11-21-80

10. WELL LOG

Depth (ft.) From	To	Formation
0	2	topsoils
2	18	clay interblended with gravels
18	44	tight claybound rocks and gravel
44	49	clay, rock & gravel
49	65	clay interblended with lenses of sands and gravels
65	76	claybound rock and gravel
76	78	dirty sands and gravels
78	97	clay, sands and gravels
97	104	dirty, tight sands and gravels
104	125	silty sands
125	129	silty, heaving, runny sands

(use separate sheet if necessary)

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Dec. 16, 1980
Date

Potts Drilling and Development
Firm Name

80730 Gallatin Road Bozeman, Mont.
Address

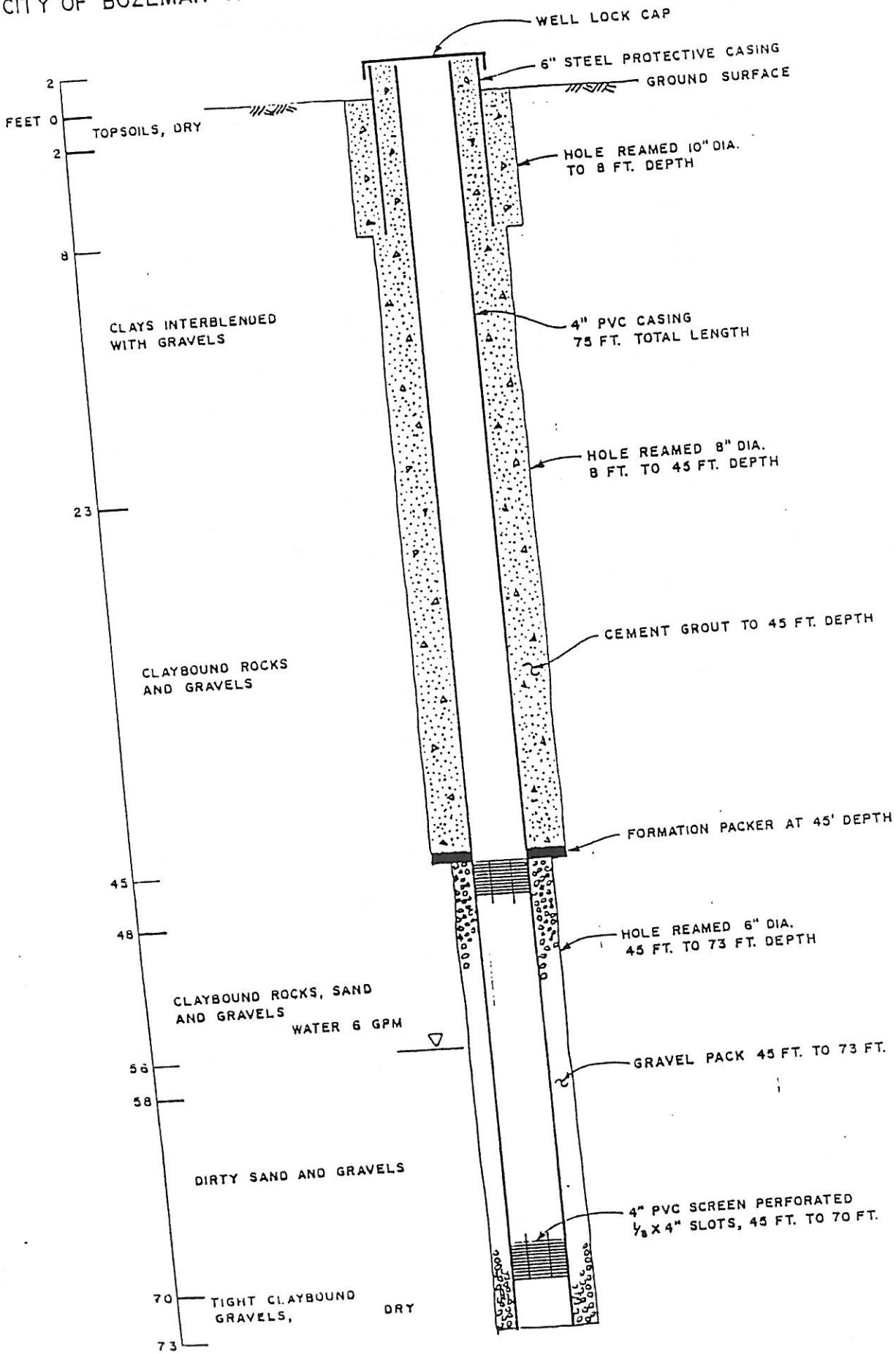
Clifford A. Potts 150
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59601 449-3634

DEPARTMENT COPY
Well owner must complete Form 602 on reverse side.

WL - 5926

CITY OF BOZEMAN SANITARY LANDFILL MONITORING #2 CENTER WELL



ROUTE ONE
BOZEMAN, MONTANA

POTTS DRILLING CO.

TELEPHONE
586-6812

Name City of Bozeman

Street Sanitary Landfill

Town Monitoring Well #2.

Location Center Well

1/4 1/4 Sec. Twp Rng

Start 11-24-80 Finish 12-2-80

Size 4" Weight pvc

Driller Herb

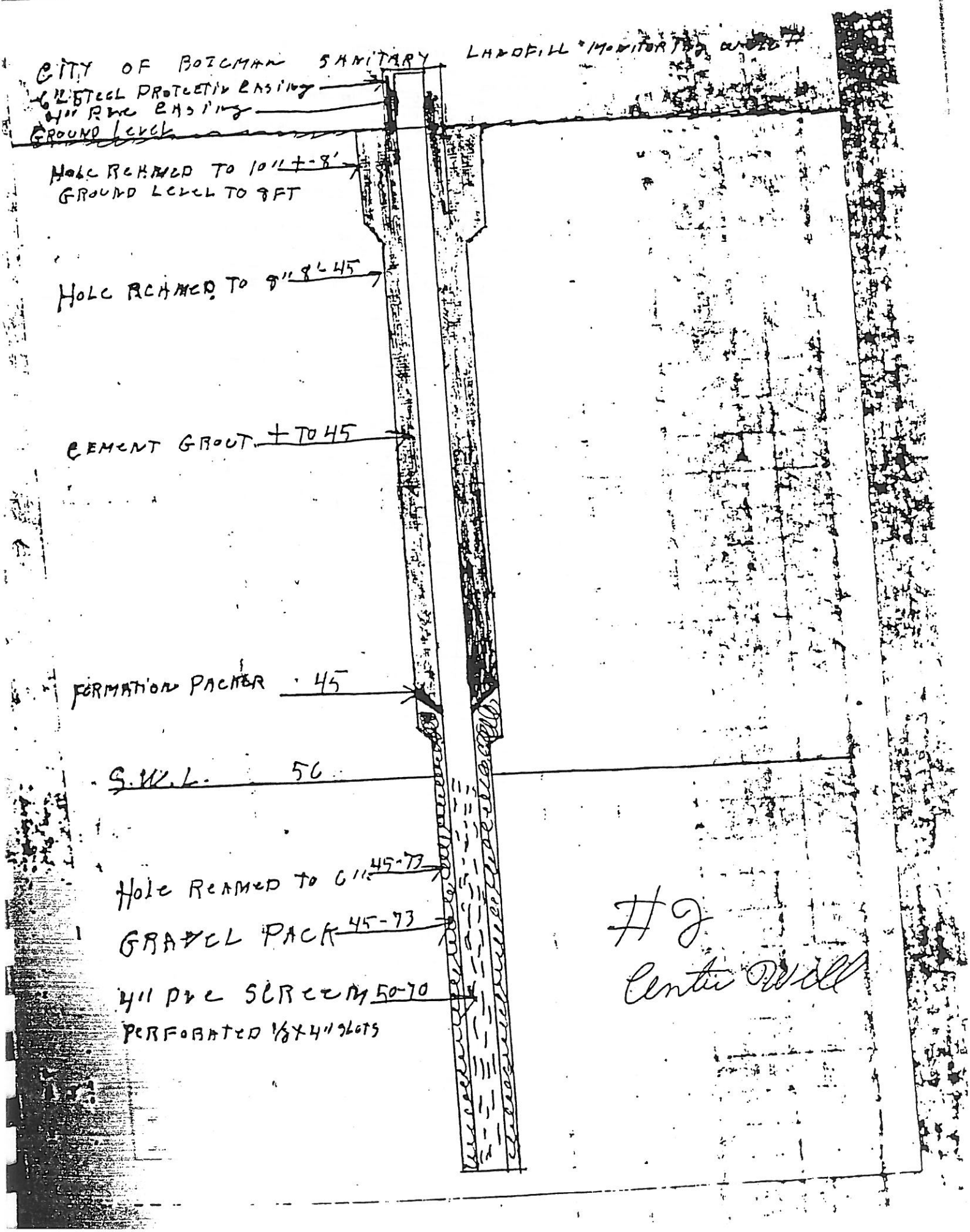
Rig 71 Star

From	To	Formation	Water
0	2	topsoils	dry
2	23	clays interblended with gravels	
23	48	claybound rocks & gravels	
48	58	claybound rocks, sand and gravels	water 6 gpm.
58	70	dirty sand & gravels	
70	73	tight clay-bound gravels	dry

CASING LOG

#	Length	Total
#1	11-28-80	58-70 ft.
	temp. 10° C.	
	Conducitivity	180
	Yield	6 gpm.
	total drilling	73 ft.
	total casing	
	4" pvc	75 ft.
	total casing	
	6" steel	10 ft.
	top of casing	± 2 ft.
	4" pvc casing perforated	
	1/8X4" slots	50-70 ft.
	gravel packed	45-70 ft.
	cement grauted	- 45 ft.
	s.w.l.	56 ft.
	amount	6 gpm.
	formation packer set at	
	45ft.	

Remarks:


CITY OF BOZEMAN SANITARY LANDFILL MONITOR WELL #7
12" STEEL PROTECTIVE CASING
4" PVC CASING
GROUND LEVEL
HOLE REAMED TO 10" +-8'
GROUND LEVEL TO 8FT
HOLE REAMED TO 9" 8'-45'
CEMENT GROUT +TO 45
FORMATION PACKER 45'
S.W.L. 56
Hole Reamed to 6" 45-73
GRAVEL PACK 45-73
4" PVC SCREEN 50-70
PERFORATED 1/8 X 4" SLOTS
#7
Centin Well

Form No 603 R10/79 77 J

File No. _____

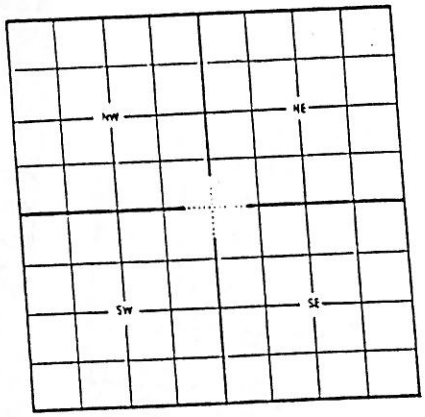
WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name City of Bozeman

2. CURRENT MAILING ADDRESS
Sanitary Landfill
Bozeman, Montana

3. WELL LOCATION



____ ¼ ____ ¼ ____ ¼ Section _____
Township _____ N/S Range _____ E/W
County Gallatin
Lot _____ Block _____
Subdivision _____
Well Elevation _____
Accuracy: ____ ± 10'; ____ ± 50'; ____ ± 100';

4. DRILLING METHOD x cable, ____ bored, ____ forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) _____

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations x and/or Screen — Kind Size	From (feet)	To (feet)
4"	pvc					
6"	steel			1/8X 4" slots	50	70'

Was casing left open end? ____ Yes ____ No
Was a packer or seal used? x Yes ____ No
If so, what material _____
Was the well gravel packed? x Yes ____ No
Was the well grouted? x Yes ____ No
To what depth? 45 ft.
Material used in grouting cement
Well head completion: Pitless adapter _____
12 in. above grade _____, other _____
(if other, specify) _____
Pump horsepower _____, pump type _____
Pump intake level _____ feet below land surface
Power (electric, diesel, etc.) _____

6. WATER LEVEL
Static water level 56 feet below land surface
If flowing, closed-in pressure _____ psi
_____ gpm flow through _____ inch pipe
Controlled by: ____ valve, ____ reducers, ____ other
(if other, specify) _____

7. WELL TEST DATA x pump x bailer air other
(if other, specify) _____
Pumping level below land surface:
65 ft. after 5 hrs. pumping 16 gpm
_____ ft. after _____ hrs. pumping _____ gpm

8. WAS WELL PLUGGED OR ABANDONED? ____ Yes x No
If yes, how? _____

9. DATE STARTED 11-24-80
DATE COMPLETED 12-2-80

10. WELL LOG

Depth (ft.) From	To	Formation
0	2	topsoils
2	23	clays, interblended with gravels
23	48	claybound rocks and gravels
48	58	claybound rock, sand and gravels
58	70	dirty sand and gravels
70	73	tight claybound gravels

(use separate sheet if necessary)

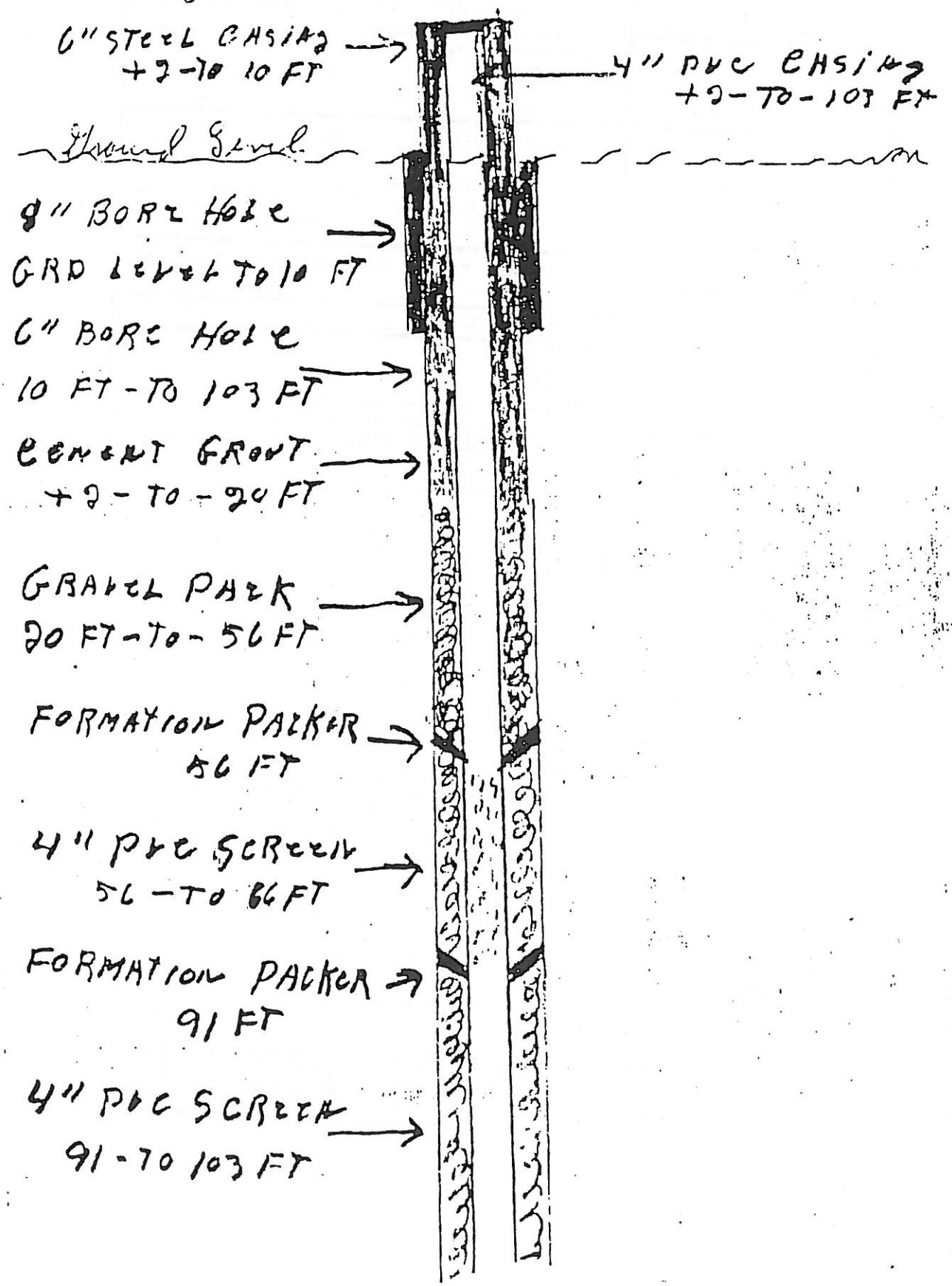
11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
Dec. 16, 1980
Potts Drilling and Developing
Firm Name
80730 Gallatin Road
Bozeman, Montana 59715
Address
Signature
150
License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59601 449-3634

DEPARTMENT COPY WL. 5927
Well owner must complete Form 602 on reverse side.

City of Bozeman
Monitoring Well #2

5-9-82



File No. _____

Form No. 603 R2/81

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name City of Bozeman

2. CURRENT MAILING ADDRESS
City Landfill Well #2
Bozeman, Montana

3. WELL LOCATION
County Gallatin
Township 1S N/S Range 6E E/W
¼ ¼ NE ¼ Section 31
Lot _____ Block _____
Subdivision _____

4. PROPOSED USE Domestic ☐ Stock ☐ Irrigation ☐
Other ☐ specify _____

5. DRILLING METHOD _____ cable, _____ bored,
_____ forward rotary, _____ reverse rotary, _____ jetted,
_____ other (specify) _____

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)
6"	6" 17#	+2	105'

Perforations _____ and/or Screen _____

Kind Size	From (feet)	To (feet)

Was casing left open end? x Yes ____ No
Was a packer or seal used? ____ Yes x No
If so, what material _____
Was the well gravel packed? ____ Yes x No
Was the well grouted? ____ Yes x No
To what depth? _____
Material used in grouting _____
Well head completion: Pitless adapter ____ Yes x No
Top of casing 12 in. or greater above grade ____ Yes x No

7. WHAT IS THE TEMPERATURE OF THE WATER?
_____ Degrees Fahrenheit
☐ Measured ☐ Estimated

8. WATER LEVEL
Static water level 56 feet below land surface
If flowing; closed-in pressure _____ psi
_____ gpm
Controlled by: _____ valve, _____ reducers,
_____ other, (specify) _____

9. WELL TEST DATA _____ pump x bailer
_____ other, (specify) _____
Pumping level below land surface:
96 ft. after 1 hrs. pumping 10 gpm
_____ ft. after _____ hrs. pumping _____ gpm

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes x No
If yes, how? _____

11. DATE COMPLETED _____, 1982

12. WELL LOG

Depth (ft.) From	To	Formation
73	91	sandy clay
91	100	gravels

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
May 19, 1982
Date
Potts Drilling and Developing
Firm Name
80730 Gallatin Rd. Bozeman, Mont.
Address
Signature 150
License No.

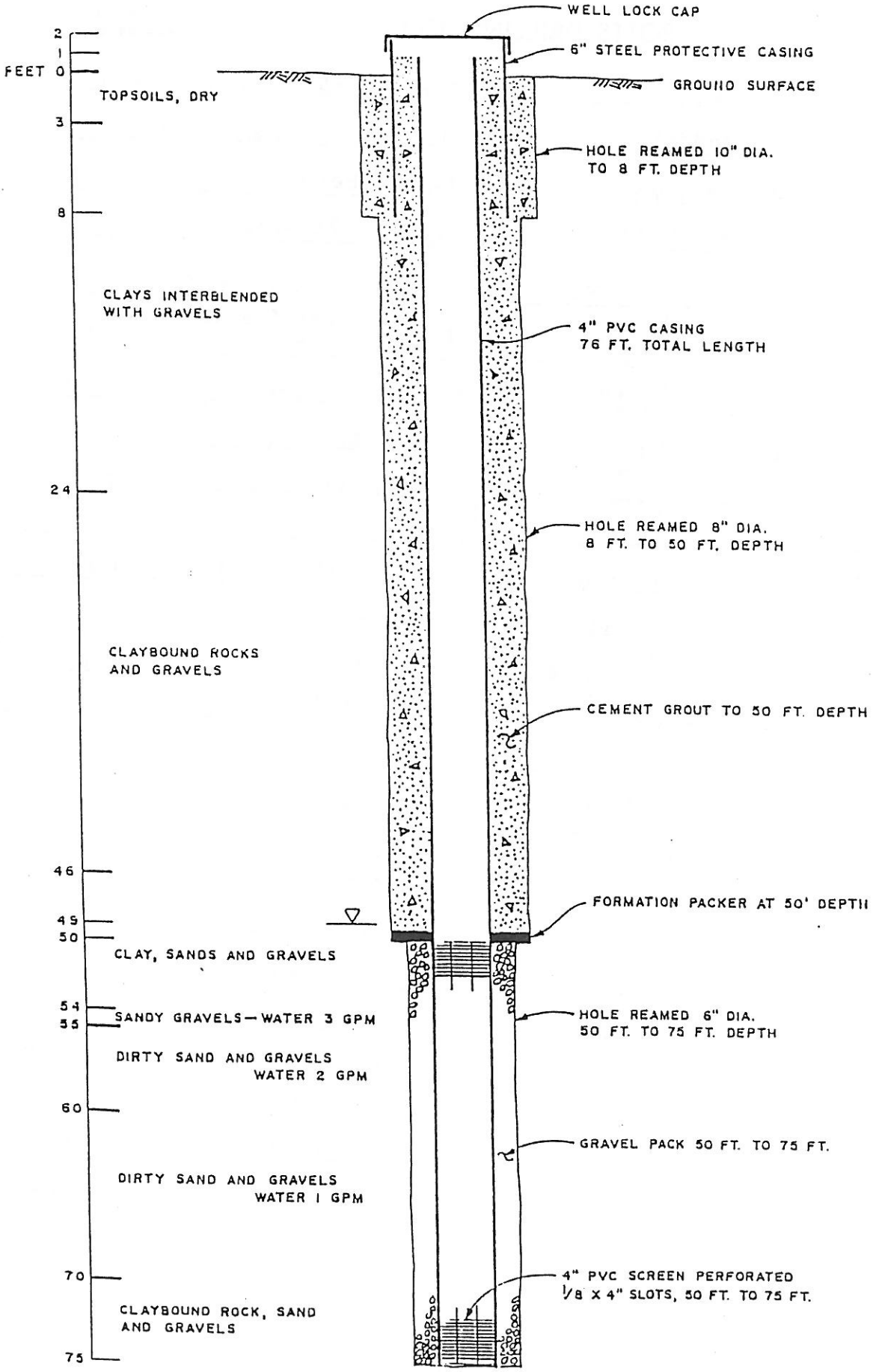
MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59620 449-3962

DEPARTMENT COPY
DRILLER: Please give this copy to the well owner to complete reverse side.
OWNER: Complete reverse side Form 602 and send to DNRC.

mitchell printers of missoula

Attachment #2

CITY OF BOZEMAN SANITARY LANDFILL MONITORING #3 SOUTH WELL



ROUTE ONE
BOZEMAN, MONTANA

POTTS DRILLING CO.

TELEPHONE
586-6812

Name City of Bozeman

Street Sanitary Landfill

Town Monituring Well #3.

Location South Boundy Well

1/4 1/4 Sec. Twp Rng

Start 12-3-80 Finish 12-12-80

Size 4" Weight pvc

Driller Herb

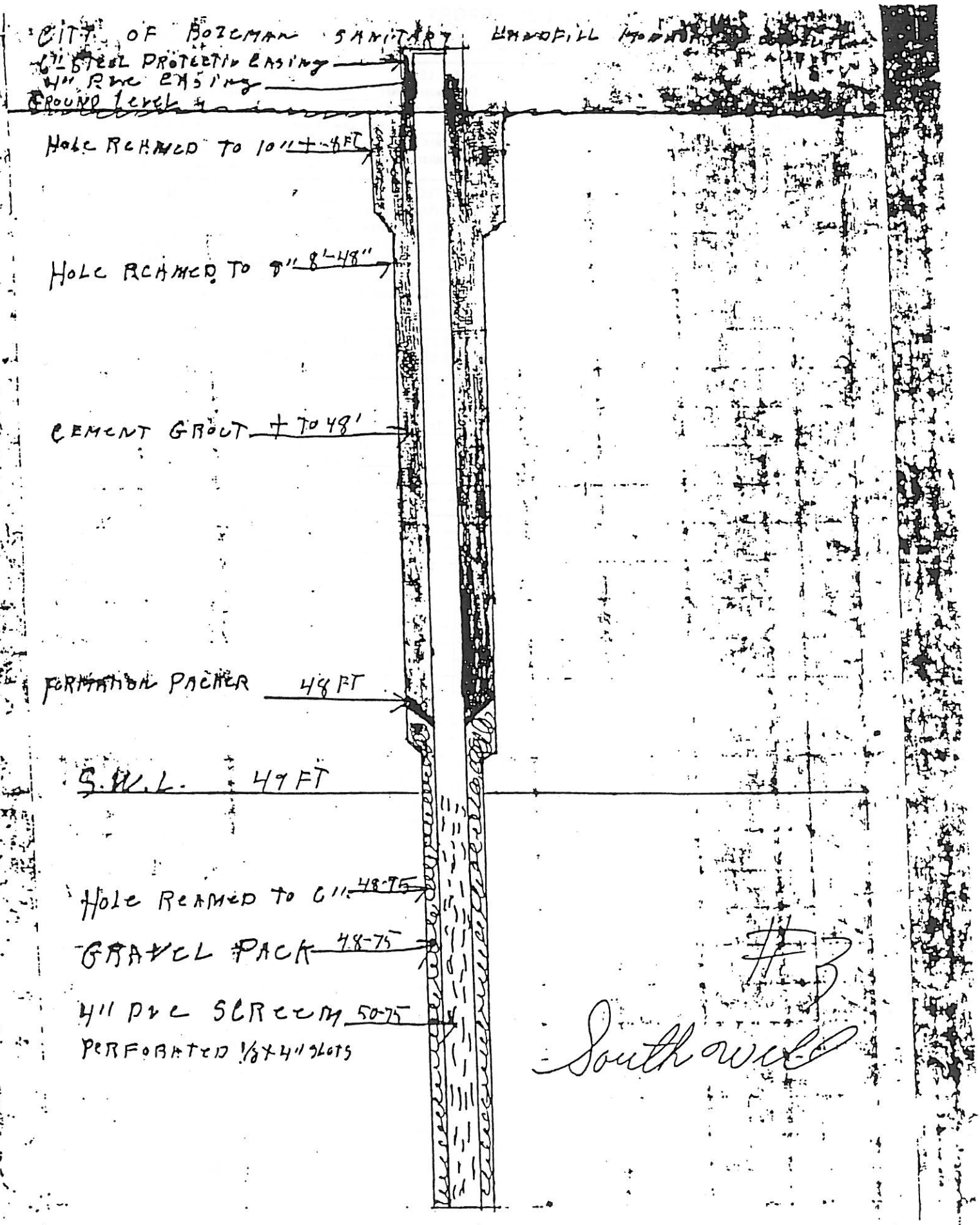
Rig 71 star

From	To	Formation	Water
0	3	topsoils	dry
3	24	clays interblended with	gravels
24	46	claybound rocks	and gravels
46	54	clay and sands,	gravels
54	55	sandy gravels	water
			3 gpm.
55	60	dirty sands & gravels	water
			2 gpm.
60	70	dirty sands and	gravels
			water 1 gpm.
70	75	claybound rock, sand and gravels	

Remarks:

CASING LOG

#	Water Sample Length	Total
#1.	12-8-80	55-60'
	temp. 105° C.	
	Conducitivity	550
	total drilling	75 ft.
	total casing	
	4" PVC	76 ft.
	total casing	
	6" Steel	10 ft.
	top of casing	+2ft.
4"	pvc casing perforated	
1/8X4"	slots	50-75ft.
	gravel packed	50-75 ft.
	formation packer set at 50 ft.	
	cement grouted to 50 ft.	
	s.w.l.	49 ft.
	amount	6 gpm.


CITY OF BOZEMAN SANITARY LANDFILL MONITOR WELL
6" ϕ STEEL PROTECTIVE CASING
4" ϕ PVC CASING
GROUND LEVEL
HOLE REAMED TO 10" ± 4FT
HOLE REAMED TO 9" 8'-48"
CEMENT GROUT ± TO 48'
FORMATION PACKER 48 FT
S.W.L. ± 47 FT
Hole Reamed to 6" 48-75
GRAVEL PACK 48-75
4" PVC SCREEN 50-75
PERFORATED 1/8 x 4" SLOTS
#3
South Well

Form No 603 R10/79

File No. _____

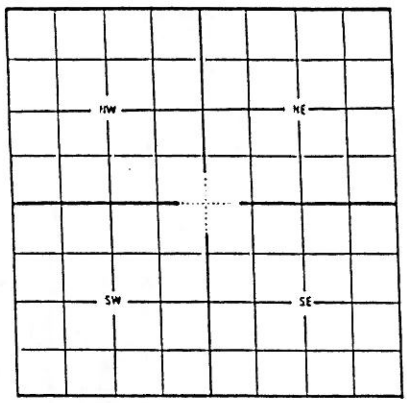
WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name City of Bozeman

2. CURRENT MAILING ADDRESS
Sanitary Landfill
Bozeman, Montana

3. WELL LOCATION



____ ¼ ____ ¼ ____ ¼ Section ____
Township ____ N/S Range ____ E/W
County Gallatin
Lot ____ Block ____
Subdivision ____
Well Elevation ____
Accuracy: ____ ± 10'; ____ ± 50'; ____ ± 100';

4. DRILLING METHOD ___x___ cable, _____ bored, _____ forward rotary, _____ reverse rotary, _____ jetted, _____ other (specify) _____

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations ___x___ and/or Screen ___ Kind Size	From (feet)	To (feet)
4" 6"	pvc steel			1/8x4" slots	50	75

Was casing left open end? ____ Yes ____ No
Was a packer or seal used? ___x___ Yes ____ No
If so, what material ~~lead~~ NEOPRENE
Was the well gravel packed? ___x___ Yes ____ No
Was the well grouted? ___x___ Yes ____ No
To what depth? 50
Material used in grouting cement
Well head completion: Pitless adapter ____
12 in. above grade ____, other ____
(if other, specify) ____
Pump horsepower ____, pump type ____
Pump intake level ____ feet below land surface
Power (electric, diesel, etc.) ____

6. WATER LEVEL
Static water level 49 feet below land surface
If flowing, closed-in pressure ____ psi
____ gpm flow through ____ inch pipe
Controlled by: ____ valve, ____ reducers, ____ other
(if other, specify) ____

7. WELL TEST DATA ___x___ pump ___x___ bailer ___x___ other
(if other, specify) ____
Pumping level below land surface:
70 ft. after 5 hrs. pumping 6 gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WAS WELL PLUGGED OR ABANDONED? ___ Yes ___x___ No
If yes, how? ____

9. DATE STARTED 12-3-80
DATE COMPLETED 12-12-80

10. WELL LOG

Depth (ft.) From	To	Formation
0	3	topsoils
3	24	clays interblended with gravels
24	46	claybounds rocks & gravels
46	54	clay and sands
54	55	sandy gravels
55	60	dirty sands and gravels
60	70	dirty sands and gravels
70	75	clybound rock, sand & gravels

(use separate sheet if necessary)

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
Dec. 16, 1980
Date
Potts Drilling and Developing
Firm Name
80730 Gallatin Road Bozeman, Montana
Address
Signature 150
License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59601 449-3634

DEPARTMENT COPY
Well owner must complete Form 602 on reverse side.

WL - 5928

Department of Natural Resources and Conservation

WELL LOG REPORT

White-Department
Yellow-Department
Pink-Well Owner
Gold-Driller

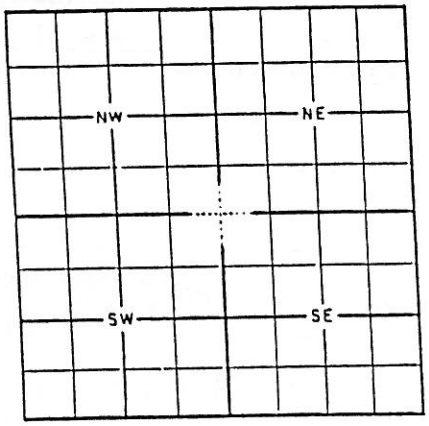
State law requires that this form be filed by the water well driller within 60 days after completion of the well, and Form 602, Notice of Completion of Groundwater Development, be filed by the well owner within 60 days after the water has been put to beneficial use.

1. WELL OWNER
Name City of Bozeman

2. CURRENT MAILING ADDRESS
Bozeman, Montana

3. PROPOSED USE ____ domestic (includes lawn and garden); ____ stock; ____ municipal; ____ industrial; ____ irrigation; ____ other (specify) ____

4. WELL LOCATION



____ ¼ ____ ¼ ____ ¼ ____ ¼ Section ____
T. ____ N or S R. ____ E or W
OR, Lot ____ Block ____
Subdivision ____
City ____ County Gallatin
Elevation ____ Accuracy: __ ±10'; __ ±50'; __ ±100';

5. DRILLING METHOD X cable, ____ bored, ____ forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify) ____

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations ____ and/or Screen ____ Kind Size	From (feet)	To (feet)
6"	6" 17#	+1' 2"	191' 5"			

Was casing left open end? X Yes, ____ No
Was a packer or seal used? ____ Yes, XX No
If so, what material X
Was the well gravel packed? ____ Yes, X No
Was the well grouted? ____ Yes, X No
To what depth? ____
Material used in grouting ____
Well head completion: Pitless adapter ____
12 in. above grade ____, other ____
(if other, specify) ____
Pump horsepower ____, pump type ____
Pump intake level ____ feet below land surface
Power (electric, diesel, etc.) ____

7. WATER LEVEL
Static water level 90' feet below land surface
If flowing, closed-in pressure ____ psi
____ gpm flow through ____ inch pipe
Controlled by: ____ valve, ____ reducers, ____ other (if other, specify) ____

8. WELL TEST DATA X pump ____ bailer ____ other (if other, specify) ____
Pumping level below land surface:
____ ft. after ____ hrs. pumping 30 gpm
____ ft. after ____ hrs. pumping ____ gpm

9. WAS WELL PLUGGED OR ABANDONED? ____ Yes X No
If yes, how? ____

10. DATE STARTED ____
DATE COMPLETED ____

11. WELL LOG

Depth (ft.) From	To	Formation
0	24	silty clay & gravel
24	26	soft clays
26	45	fine clays
45	58	hard clays
58	61	soft clays
61	69	hard clays
69	75	dirty gravel
75	95	very tight dirty claybound gravel
95	99	clays and gravels
99	109	dirty, wet gravels
109	111	broken rock
111	125	dirty, wet gravels
125	127	tight dirty sand and gravels
127	132	very dirty silty clay sands and gravels
132	135	tight sands and gravel
135	149	claybound gravels and sand
149	157	silty sands and gravel
157	174	clay
174	176	coarse to fine sands and gravel
176	187	claybound sand and gravel
187	193	clay
193	200	coarse gravels and sand
200	205	coarse sands and gravels

(use separate sheet if necessary)

12. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge. Oct. 10, 1979
Date

Potts Drilling and Developing
Firm Name

80730 Gallatin Road Bozeman, Mont.
Address

Winfield Potts 150
Signature License No.

MONTANA BUREAU OF MINES AND GEOLOGY | WELL LOG | GROUND WATER DIVISION

County Gallatin Location: T. 1 S R. 6 E Sec. 30 Tract CDDD Hole name or number LF-1

Hole location

Recorded by H.R.M. Date hole started 2/20/85 Date hole completed 2/20/85 Driller F.A.S. Drilling company MBMG

Total well depth (ft.) 23 Well diameter(s) 6" Casing diameter(s) and length(s) 4"

Type of casing(s): A. Steel (black) (C) Plastic E. Wood cribbing
B. Steel (gal.) D. Open hole F. Other (specify)

Weight or gage of casing 160 Method–perforated or screened: saw slots

A. No casing in hole
B. Open bottom only
C. Slotted with Mill's knife
D. Slotted with a torch
E. Screened by pulling casir
F. Other (specify)

Interval–perforated or screened: 18-22.5

Has or will well be test pumped? Yes No Were material samples taken? (Yes) No Was a water sample(s) taken? Yes No

Remarks

From	To	DRILLING LOG Geological, drilling, and water conditions; remarks and sampling	Estimated composition, % Gravel c	f	Sand vc	c	m	f	vf	silt	cl
0	3	Top soil, dark brown, silty									
3	8	Silt, clayey, dark brown to black									
8	13	Clay, silty, black, gravels ≈ 13'									
13	14	Gravel, very coarse with angular sandstone fragments									
14	18	Clay, silty, black with gravels and angular fragments									
18	23	Sand, med-coarse with some gravels									
		saturated 18'-18.5'									
		Static ≈ 15'									

MBMG WELL COMPLETION DATA HYDROLOGY DIVISION

Project	Other
Hole Number LF-1	Blank Casing
Hole Location	Screen
Drilling Dates 2/20/85 2/20/85	Packer
Driller & Company MBMG	Cap
Design By	Bentonite Pellets
Hole Diameter 6"	Bentonite Slurry
Total Depth 23	Cement
Casing Diameter 4"	Gravel
Casing Type & Gauge PVC-160	Cuttings
Land Surface Elevation	Other Caved Material

Remarks

DEPTHS (ft.)	COMPLETION T.C.	COMPLETION G.S.	MATERIAL	THICKNESS (ft.)	MATERIAL SIZE OR MAKE	LITHOLOGY	OTHER
0' 3'							
18'							
23'							
28'	TD						

MONTANA BUREAU OF MINES AND GEOLOGY

WELL LOG

GROUND WATER DIVISION

County Gallatin Location: T. 1 S R. 6 E Sec. 30 Tract CDDD Hole name or number LF-1A

Hole location

Recorded by H.R.M. Date hole started 2/20/85 Date hole completed 2/20/85 Driller F.A.S. Drilling company MBMG

Total well depth (ft.) 33 Well diameter(s) 8" Casing diameter(s) and length(s) 4"

Type of casing(s): A. Steel (black) B. Steel (gal.) (C.) Plastic D. Open hole E. Wood cribbing F. Other (specify)

Weight or gage of casing PVC-160 Method—perforated or screened: saw slots

A. No casing in hole
B. Open bottom only
C. Slotted with Mill's knife
D. Slotted with a torch
E. Screened by pulling casing
F. Other (specify)

Interval—perforated or screened: 22'-23.5'

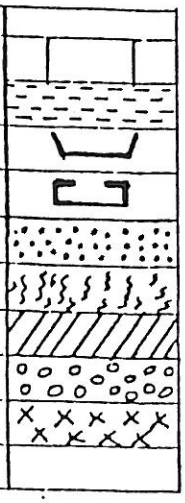
Has or will well be test pumped? Yes No Were material samples taken? (Yes) No Was a water sample(s) taken? Yes No

Remarks

From	To	DRILLING LOG Geological, drilling, and water conditions; remarks and sampling	Estimated composition, % Gravel c	f	Sand vc	c	m	f	vf	silt	clay
0	3	Top soil, dark brown, silty									
3	8	Silt, clayey, dark brown to black									
8	13	Clay, silty, black, gravel ≈ 13'									
13	14	Gravel, very coarse with angular fragments, sandstone									
14	18	Clay, silty, black with gravels and angular fragments									
18	23	Sand, med-coarse with some gravels									
23	28	No return - drilling - alternating grinding (gravels) and soft drilling (clay)									
28	29	No return - grinding (gravels)									
29	33	No return - grinding (gravels)									

MBMG WELL COMPLETION DATA HYDROLOGY DIVISION

Project	Other
Hole Number LF-1A	Blank Casing
Hole Location	Screen
Drilling Dates 2/20/85 - 2/26/85	Packer
Driller & Company MBMG	Cap
Design By	Bentonite Pellets
Hole Diameter 8"	Bentonite Slurry
Total Depth 33'	Cement
Casing Diameter 4"	Gravel
Casing Type & Gauge PVC-160	Cuttings
Land Surface Elevation	Other



Remarks

DEPTHS (ft.)	COMPLETION T.C. G.S.		MATERIAL	THICKNESS (ft.)	MATERIAL SIZE OR GRADE	LITHOLOGY	OTHER
0' 2'							
22'							
24'							
33'	TD						

MONTANA BUREAU OF MINES AND GEOLOGY — WELL LOG — GROUND WATER DIVISION

County Gallatin Location: T. 1 S R. 6 E Sec. 31 Tract ABBC Hole name or number LF-2

Hole location

Recorded by H.R.M. Date hole started 2/21/85 Date hole completed 2/21/85 Driller F.A.S. Drilling company MBMG

Total well depth (ft.) 28 Well diameter(s) 6" Casing diameter(s) and length(s) 4"

Type of casing(s): A. Steel (black) (C) Plastic E. Wood cribbing B. Steel (gal.) D. Open hole F. Other (specify) Weight or gage of casing 160 Method—perforated or screened:

A. No casing in hole
B. Open bottom only
C. Slotted with Mill's knife
D. Slotted with a torch
E. Screened by pulling casin
F. Other (specify) saw slots

Interval—perforated or screened: 12'-17.5'

Has or will well be test pumped? Yes No Were material samples taken? (Yes) No Was a water sample(s) taken? Yes No

Remarks

From	To	DRILLING LOG Geological, drilling, and water conditions; remarks and sampling	Estimated composition, % Gravel c	f	Sand vc	c	m	f	vf	silt	cla
0	1	Top soil, silty, black									
1	3	Silt, clayey, dark brown									
3	8	Clay, silty, light brown, very moist									
8	12	Same as above									
12	13	Gravels, sandy									
13	17	Gravels, coarse to very coarse, sandy									
17	18	Sand									
18	20	Gravel									
20	22	No return, soft drilling									
22	23	Gravels, silty, saturated									

MBMG WELL COMPLETION DATA HYDROLOGY DIVISION

Project	Other
Hole Number LF-2	Blank Casing
Hole Location	Screen
Drilling Dates S-2/21/85 C-2/21/85	Packer
Driller & Company MBMG	Cap
Design By HRM-FAS	Bentonite Pellets
Hole Diameter 6"	Bentonite Slurry
Total Depth 23'	Cement
Casing Diameter 4"	Gravel
Casing Type & Gauge 160 PVC	Cuttings
Land Surface Elevation	Other Caved Material

Remarks

DEPTHS (ft.)	COMPLETION T.C. G.S.	MATERIAL	THICKNESS (ft.)	MATERIAL SIZE OR MAKE	LITHOLOGY	OTHER
0 1.6						
10'						
12'						
18'						
23' TD						

- no grout in bentonite

MONTANA BUREAU OF MINES AND GEOLOGY — WELL LOG — GROUND WATER DIVISION

County Gallatin Location: T. 1 S R. 6 E Sec. 31 Tract ABAA Hole name or number LF-3

Hole location

Recorded by H.R.M. Date hole started 2/21/85 Date hole completed 2/21/85 Driller F.A.S. Drilling company MBMG

Total well depth (ft.) 48 Well diameter(s) 6" Casing diameter(s) and length(s) 4"

Type of casing(s): A. Steel (black) (C) Plastic E. Wood cribbing B. Steel (gal.) D. Open hole F. Other (specify)

Weight or gage of casing 160

Method—perforated or screened: A. No casing in hole B. Open bottom only C. Slotted with Mill's knife D. Slotted with a torch E. Screened by pulling casi F. Other (specify) saw slots

Interval—perforated or screened: 31.5'-36'

Has or will well be test pumped? Yes No Were material samples taken? (Yes) No Was a water sample(s) taken? Yes No

Remarks

From	To	DRILLING LOG Geological, drilling, and water conditions; remarks and sampling	Estimated composition, % Gravel c	f	Sand vc	c	m	f	vf	silt	cl
0	2	Top soil, silty, black									
2	3	Silt, clayey, light brown									
3	8	Silt, light brown									
8	9	Gravel									
9	13	Silt, light brown									
13	14	Silt, light brown									
14	18	Alternating very fine and very coarse gravels with silty									
		sand very fine, light brown									
18	23	Same as above									
23	28	Gravel with silt, black (moist)									
28	30	Silt, saturated ≈ 29'									
31	33	Silt, saturated									
33	38	Sand, clayey, dark brown, saturated									
38	48	No return									

MBMG WELL COMPLETION DATA HYDROLOGY DIVISION

Project	Other
Hole Number LF-3	Blank Casing
Hole Location	Screen
Drilling Dates 2/21/85 - 2/21/85	Packer
Driller & Company M.B.M.G.	Cap
Design By F.A.S. - H.R.M.	Bentonite Pellets
Hole Diameter 6"	Bentonite Slurry
Total Depth 48'	Cement
Casing Diameter 4"	Gravel
Casing Type & Gauge PVC - 160	Cuttings
Land Surface Elevation	Other Caved Material

Remarks

DEPTHS (ft.)	COMPLETION	MATERIAL	THICKNESS (ft.)	MATERIAL SIZE OR MAKE	LITHOLOGY	OTHER
0' 3'	T.C. G.S.					
8'						
14'						
31.5'						
36.5'						
48'	TD					

filter pack weighs offset of bentonite 4 or 5'

MONTANA BUREAU OF MINES AND GEOLOGY | WELL LOG | GROUND WATER DIVISION

County Gallatin Location: T. 1S R. 6E Sec. 31 Tract ABCD Hole name or number LF-4

Hole location

Recorded by H.R.M. Date hole started 2/22/85 Date hole completed 2/22/85 Driller F.A.S. Drilling company MBMG

Total well depth (ft.) 23 Well diameter(s) 6" Casing diameter(s) and length(s) 4"

Type of casing(s): A. Steel (black) (C) Plastic E. Wood cribbing B. Steel (gal.) D. Open hole F. Other (specify)

Weight or gage of casing 160

Method–perforated or screened: saw slots

A. No casing in hole
B. Open bottom only
C. Slotted with Mill's knife
D. Slotted with a torch
E. Screened by pulling casi
F. Other (specify)

Interval–perforated or screened: 5'-12.5'

Has or will well be test pumped? Yes No Were material samples taken? (Yes) No Was a water sample(s) taken? Yes No

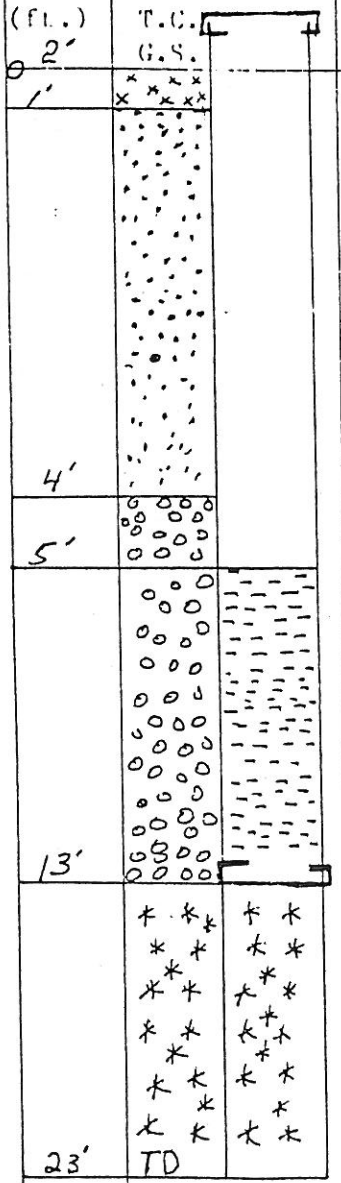
Remarks

From	To	DRILLING LOG Geological, drilling, and water conditions; remarks and sampling	Estimated composition, % Gravel c	f	Sand vc	c	m	f	vf	silt	cl
0	3	Clay, silty, black, very moist									
3	4	Clay, silty, very tight, light brown, very moist									
4	7	Sand, very fine, clayey, light brown, saturated									
7	7.5	Gravel, sandy, very fine									
7.5	8	Sand, very fine to fine, clayey, light brown, saturated									
8	10	Gravels, medium									
10	13	Clay, sandy									
13	18	No return, grinding (gravels)									
18	23	Same as above									

MBMG WELL COMPLETION DATA HYDROLOGY DIVISION

Project	Other
Hole Number LF-4	Blank Casing
Hole Location	Screen
Drilling Dates 2/22/85 (start) - 2/22/85 (complete)	Packer
Driller & Company MBMG	Cap
Design By HRM-FAS	Bentonite Pellets
Hole Diameter 6"	Bentonite Slurry
Total Depth 23'	Cement
Casing Diameter 4"	Gravel
Casing Type & Gauge 160 PVC	Cuttings
Land Surface Elevation	Other Caved Material

Remarks



DEPTHS (ft.)	MATERIAL	THICKNESS (ft.)	MATERIAL SIZE OR MAKE	LITHOLOGY	OTHER
0 - 1'	Cuttings	1'			
1' - 4'	Bentonite Pellets	3'			
4' - 5'	Gravel	1'			
5' - 13'	Screen	8'			
13' - 23' TD	Caved Material	10'			

OK

4-

MONTANA BUREAU OF MINES AND GEOLOGY — WELL LOG — GROUND WATER DIVISION

County Gallatin Location: T. 1S R. 6E Sec. 31 Tract ABBC Hole name or number LF - 5

Hole location

Recorded by HRM Date hole started 2/27/85 Date hole completed 2/27/85 Driller FAS Drilling company MBMG

Total well depth (ft.) 13' Well diameter(s) 6" Casing diameter(s) and length(s) 4"

Type of casing(s): A. Steel (black) B. Steel (gal.) (C.) Plastic D. Open hole E. Wood cribbing F. Other (specify)

Weight or gage of casing

Method–perforated or screened: saw slot

A. No casing in hole
B. Open bottom only
C. Slotted with Mill's knife
D. Slotted with a torch
E. Screened by pulling casing
F. Other (specify)

Interval–perforated or screened: 6.5' - 11.0'

Has or will well be test pumped? Yes No Were material samples taken? (Yes) No Was a water sample(s) taken? Yes No

Remarks

From	To	DRILLING LOG Geological, drilling, and water conditions; remarks and sampling	Estimated composition, % Gravel c	f	Sand vc	c	m	f	vf	silt	cla
0	3	clay, black, very tight, organics									
3	4	same as above									
4	5	clay, sandy, black(peat) saturated x 4'									
5	6	clay, light blue, very tight with peat stringers									
6	7	peat, clayey									
7	8	sand, clayey, light blue fine to coarse with peat stringers									
8	10	gravel									
10	13	alternating sand (fine) and gravel									

MBMG WELL COMPLETION DATA HYDROLOGY DIVISION

Project	Other
Hole Number LF-5	Blank Casing
Hole Location	Screen
Drilling Dates 2/27/85 - 2/27/85	Packer
Driller & Company MBMG	Cap
Design By FAS-HRM	Bentonite Pellets
Hole Diameter 6"	Bentonite Slurry
Total Depth 13'	Cement
Casing Diameter 4"	Gravel
Casing Type & Gauge PVC-160	Cuttings
Land Surface Elevation	Other Caved Material

Remarks

DEPTHS (ft.) 0' 2'	COMPLETION T.C. C.S.	MATERIAL	THICKNESS (ft.)	MATERIAL SIZE OR MAKE	LITHOLOGY	OTHER
6.5'						
11.5						
13' TD						

no grout
no bentonite

5'

MONTANA BUREAU OF MINES AND GEOLOGY — WELL LOG — GROUND WATER DIVISION

County Gallatin Location: T. 1S R. 6E Sec. 31 Tract BABA Hole name or number LF-6

Hole location

Recorded by H.R.M. Date hole started 2/27/85 Date hole completed 2/27/85 Driller F.A.S. Drilling company MBMG

Total well depth (ft.) 18 Well diameter(s) 6" Casing diameter(s) and length(s) 4"

Type of casing(s): A. Steel (black) B. Steel (gal.) (C.) Plastic D. Open hole E. Wood cribbing F. Other (specify)

Weight or gage of casing 160

Method—perforated or screened: A. No casing in hole B. Open bottom only C. Slotted with Mill's knife D. Slotted with a torch E. Screened by pulling casi F. Other (specify) saw slots

Interval—perforated or screened: 10'-11.5'

Has or will well be test pumped? Yes No Were material samples taken? (Yes) No Was a water sample(s) taken? Yes No

Remarks

From	To	DRILLING LOG Geological, drilling, and water conditions; remarks and sampling	Estimated composition, % Gravel c	Gravel f	Sand vc	Sand c	Sand m	Sand f	Sand vf	silt	cl
0	1	Clay, black, very tight									
1	2	Peat, clayey, very tight									
2	3	Clay, silty, light blue, oxidized zones (Fe)									
3	6	Sand, very coarse, light green to gray with medium gravels									
		throughout saturated ≈ 3'-4'									
6	8	Sand, very coarse, silty with gravels									
8	9	No return - grinding (gravels)									
9	10	No return - soft drilling (clay)									
10	12	No return - grinding (gravels)									
12	13	No return - soft drilling (clay)									
13	18	Alternating sand and gravel									

MBMG WELL COMPLETION DATA HYDROLOGY DIVISION

Project	Other
Hole Number LF-6	Blank Casing
Hole Location	Screen
Drilling Dates 2/27/85 - 2/27/85	Packer
Driller & Company MBMG	Cap
Design By FAS - HRM	Bentonite Pellets
Hole Diameter 6"	Bentonite Slurry
Total Depth 18'	Cement
Casing Diameter 4"	Gravel
Casing Type & Gauge PVC-160	Cuttings
Land Surface Elevation	Other

Remarks

DEPTHS (ft.)	COMPLETION	MATERIAL	THICKNESS (ft.)	MATERIAL SIZE OR NAME	LITHOLOGY	OTHER
0	T.C. G.S.					
2'						
6'						
10'						
12'						
18'	TD					

& no surface seal - less bentonite

MONTANA BUREAU OF MINES AND GEOLOGY — WELL LOG — GROUND WATER DIVISION

County Gallatin Location: T. 1 S R. 6 E Sec. 31 Tract BABA Hole name or number LF-6A

Hole location

Recorded by H.R.M. Date hole started 2/27/85 Date hole completed 2/27/85 Driller F.A.S. Drilling company MBMG

Total well depth (ft.) 8 Well diameter(s) 6" Casing diameter(s) and length(s) 4"

Type of casing(s): A. Steel (black) (C.) Plastic E. Wood cribbing — B. Steel (gal.) D. Open hole F. Other (specify)

Weight or gage of casing 160

Method–perforated or screened:

A. No casing in hole
B. Open bottom only
C. Slotted with Mill's knife
D. Slotted with a torch
E. Screened by pulling casi
F. Other (specify) saw slot

Interval–perforated or screened: 4.5'-7.0'

Has or will well be test pumped? Yes No Were material samples taken? (Yes) No Was a water sample(s) taken? Yes No

Remarks

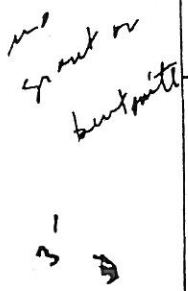
From	To	DRILLING LOG Geological, drilling, and water conditions; remarks and sampling	Estimated composition, % Gravel c	Gravel f	Sand vc	Sand c	Sand m	Sand f	Sand vf	silt	cl
0	1	Clay, black, very tight									
1	2	Peat, clayey, very tight									
2	3	Clay, silty, light blue, oxidized zones (Fe)									
3	6	Sand, very coarse, light green to gray with medium gravels throughout, saturated ≈ 3'-4'									
6	8	Sand, very coarse, silty, with gravels									

MBMG WELL COMPLETION DATA HYDROLOGY DIVISION

Project	Other
Hole Number LF-6A	Blank Casing
Hole Location	Screen
Drilling Dates 2/27/85 - 2/27/85	Packer
Driller & Company MBMG	Cap
Design By HRM - FAS	Bentonite Pellets
Hole Diameter 6"	Bentonite Slurry
Total Depth 8'	Cement
Casing Diameter 4"	Gravel
Casing Type & Gauge PVC-160	Cuttings
Land Surface Elevation	Other Caved Material

Remarks

DEPTHS (Ft.)	COMPLETION T.C. G.S.	MATERIAL	THICKNESS (Ft.)	MATERIAL SIZE OR MAKE	LITHOLOGY	OTHER
0 2'						
3'						
4.5'						
7.5'						
8'	TD					



MONTANA BUREAU OF MINES AND GEOLOGY — WELL LOG — GROUND WATER DIVISION

County Gallatin Location: T. 1S R. 6E Sec. 31 Tract BAAD Hole name or number LF-7

Hole location

Recorded by H.R.M. Date hole started 2/27/85 Date hole completed 2/27/85 Driller F.A.S. Drilling company MBMG

Total well depth (ft.) 21 Well diameter(s) 6" Casing diameter(s) and length(s) 4"

Type of casing(s): A. Steel (black) (C.) Plastic E. Wood cribbing B. Steel (gal.) D. Open hole F. Other (specify)

Weight or gage of casing 160

Method–perforated or screened:
A. No casing in hole
B. Open bottom only
C. Slotted with Mill's knife
D. Slotted with a torch
E. Screened by pulling casin
F. Other (specify) saw slots

Interval–perforated or screened: 11.5'-12.5'

Has or will well be test pumped? Yes No Were material samples taken? (Yes) No Was a water sample(s) taken? Yes No

Remarks

From	To	DRILLING LOG Geological, drilling, and water conditions; remarks and sampling	Estimated composition, % Gravel c	f	Sand vc	c	m	f	vf	silt	cla
0	1	Silt, clayey, light brown									
1	3	Clay, light brown, salt stringers									
3	4	Clay, black, very tight, peat stringers									
4	6	Clay, black, very tight									
6	8	Clay, light brown, silty, very tight, oxidized stringers (Fe)									
		very moist									
8	9	Same as above									
9	11	Gravel, sandy, very fine to fine, saturated									
11	12	Clay, tight, with some gravels									
12	14	Gravels									
14	21	No return - grinding (gravels)									

MBMG WELL COMPLETION DATA HYDROLOGY DIVISION

Project	
Hole Number LF-7	
Hole Location	
Drilling Dates S-2/27/85 C-2/27/85	
Driller & Company MBMG	
Design By FAS-HRM	
Hole Diameter 6"	
Total Depth 21'	
Casing Diameter 4"	
Casing Type & Gauge 160 PVC	
Land Surface Elevation	

Other
Blank Casing
Screen
Packer
Cap
Bentonite Pellets
Bentonite Slurry
Cement
Gravel
Cuttings
Other Caved Material

Remarks Bentonite ½ of screen couldn't install screen was enough

DEPTHS (Ft.)	COMPLETION T.C. G.S.	MATERIAL	THICKNESS (ft.)	MATERIAL SIZE OR MAKE	LITHOLOGY	OTHER
0 1'						
4'						
8.5'						
10'						
11.5'						
13'						
21'	TD					

- no surface seal
- bentonite in screen

MONTANA BUREAU OF MINES AND GEOLOGY — WELL LOG — GROUND WATER DIVISION

County Gallatin Location: T. 1S R. 6E Sec. 31 Tract BAAD Hole name or number LF-7A

Hole location

Recorded by H.R.M. Date hole started 2/27/85 Date hole completed 2/27/85 Driller F.A.S. Drilling company MBMG

Total well depth (ft.) 11.5 Well diameter(s) 6" Casing diameter(s) and length(s) 4"

Type of casing(s): A. Steel (black) (C) Plastic E. Wood cribbing B. Steel (gal.) D. Open hole F. Other (specify)

Weight or gage of casing 160 Method—perforated or screened: saw slots

A. No casing in hole
B. Open bottom only
C. Slotted with Mill's knife
D. Slotted with a torch
E. Screened by pulling casi
F. Other (specify)

Interval—perforated or screened: 8'-10.5'

Has or will well be test pumped? Yes No Were material samples taken? (Yes) No Was a water sample(s) taken? Yes No

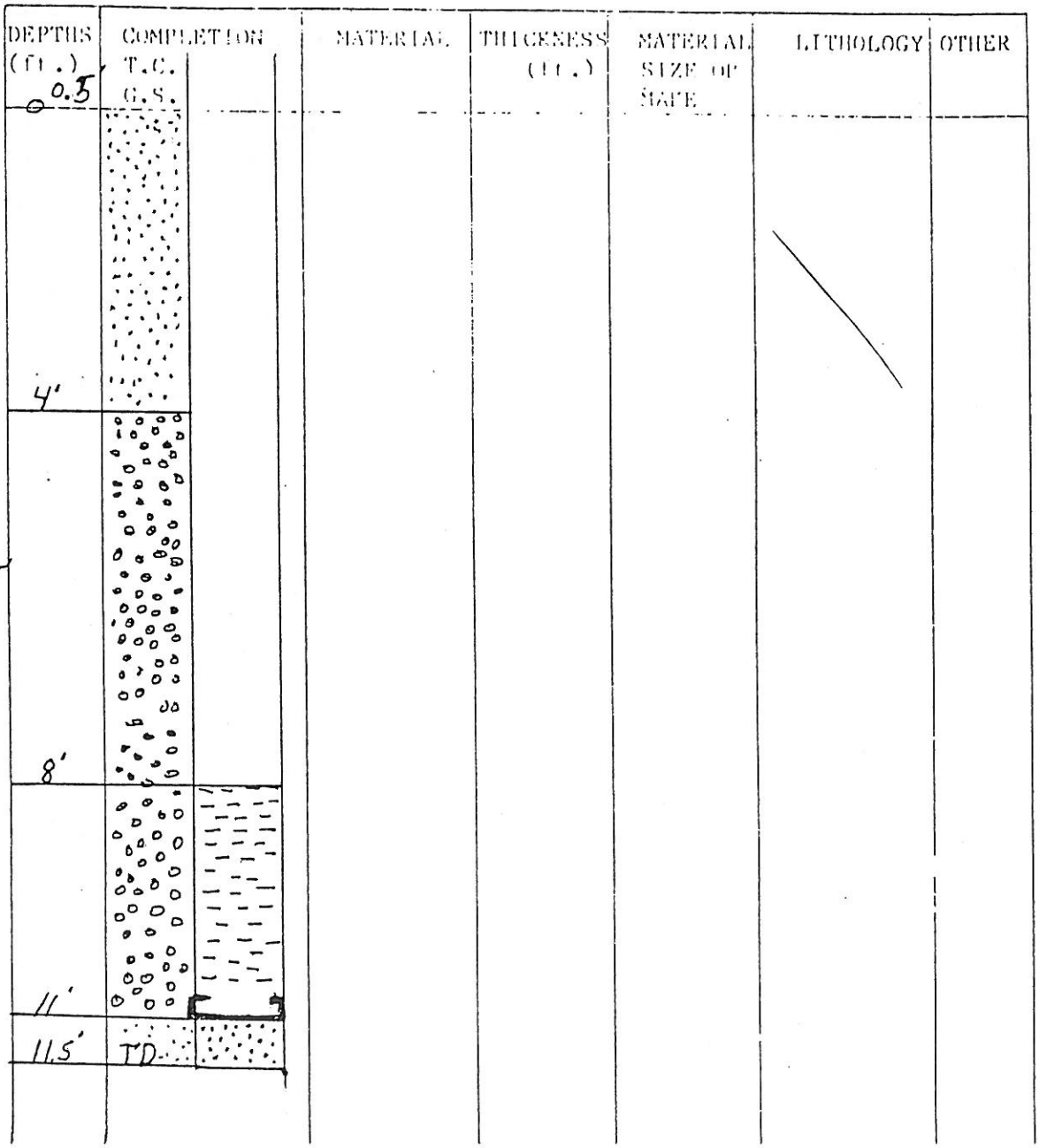
Remarks

From	To	DRILLING LOG Geological, drilling, and water conditions: remarks and sampling	Estimated composition, % Gravel c	f	Sand vc	c	m	f	vf	silt	cl
0	1	Silt, clayey, light brown									
1	3	Clay, light brown, salt stringers									
3	4	Clay, black, very tight, peat stringers									
4	6	Clay, black, very tight									
6	8	Clay, light brown, silty, very tight, oxidized stringers (Fe)									
		very moist									
8	9	Same as above									
9	11	Gravel, sandy, very fine to fine, saturated									
11	11.5	Clay, tight, with some gravel									

MBMG WELL COMPLETION DATA HYDROLOGY DIVISION

Project	Other
Hole Number LF-7A	Blank Casing
Hole Location	Screen
Drilling Dates S-2/27/85 C-2/27/85	Packer
Driller & Company MBMG	Cap
Design By HRM-FAS	Bentonite Pellets
Hole Diameter 6"	Bentonite Slurry
Total Depth 11.5'	Cement
Casing Diameter 4"	Gravel
Casing Type & Gauge 160 PVC	Cuttings
Land Surface Elevation	Other

Remarks



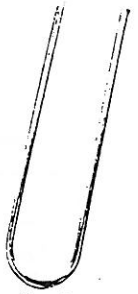
OK

- no annular seal

- no apron

3

Stiller and Associates, Inc
Consulting Hydrologists – Geologists – Engineers



Hole Name

MONITORING WELL LOG

State Montana County Gallatin Project: Bozeman Landfill or Number: M-4

Legal Descriptive
Location: T 1S R 6E Sec 30 Tract CDD Location: 185' NNW of LF-1

Recorded by: Dunlavy Date Hole Started: 05/08/86 Date Hole Completed: 05/10/86 1415 Hrs. 1200 Hrs. Driller: Joe and Lawrence Drilling Company: Mahurin

Drill Method: Cable Tool Drilling Fluids Used: City of Bozeman Water Pilot Hole Diameter: 6" Reamed Hole Diameter: 7.5"

Total Depth Drilled: 39.0' Total Depth Reamed: 39.0' Total Depth Cased Below G.S.: 37.0' Diameter and Type of Casing: 4" Flush-Threaded PVC

Weight or Gage of Casing: SCH 40 Interval Perforated or Screened Below G.S.: 27'-37' Target Aquifer: Tertiary Alluv. Packer Type and Depth Below G.S.: N/

DURING INSTALLATION WAS:	YES	NO		Method Perforated or Screened
Well Developed?	x		(Surge Bailer &	No casing in hole.
Well Test Pumped?		x	Hand Bailer)	Open bottom only.
Water Samples Taken?	x			Slotted with Mill's Knife.
Material Samples Taken?	x			Slotted with a torch (steel).
E-Logs?		x		Screened by pulling casing.
				Saw cut (pvc).
			x	Other (specify) 0.030" Factory Slot

Static Water Level: 27.4 (Ft) Date: 05/10/86
20.6 (Ft) 05/14/86

Measuring Point Description/Elevation: Top of PVC/901.0' (assume 1000 @ control well) MP Height Above (+/-) or Below G.S.: (+).7'

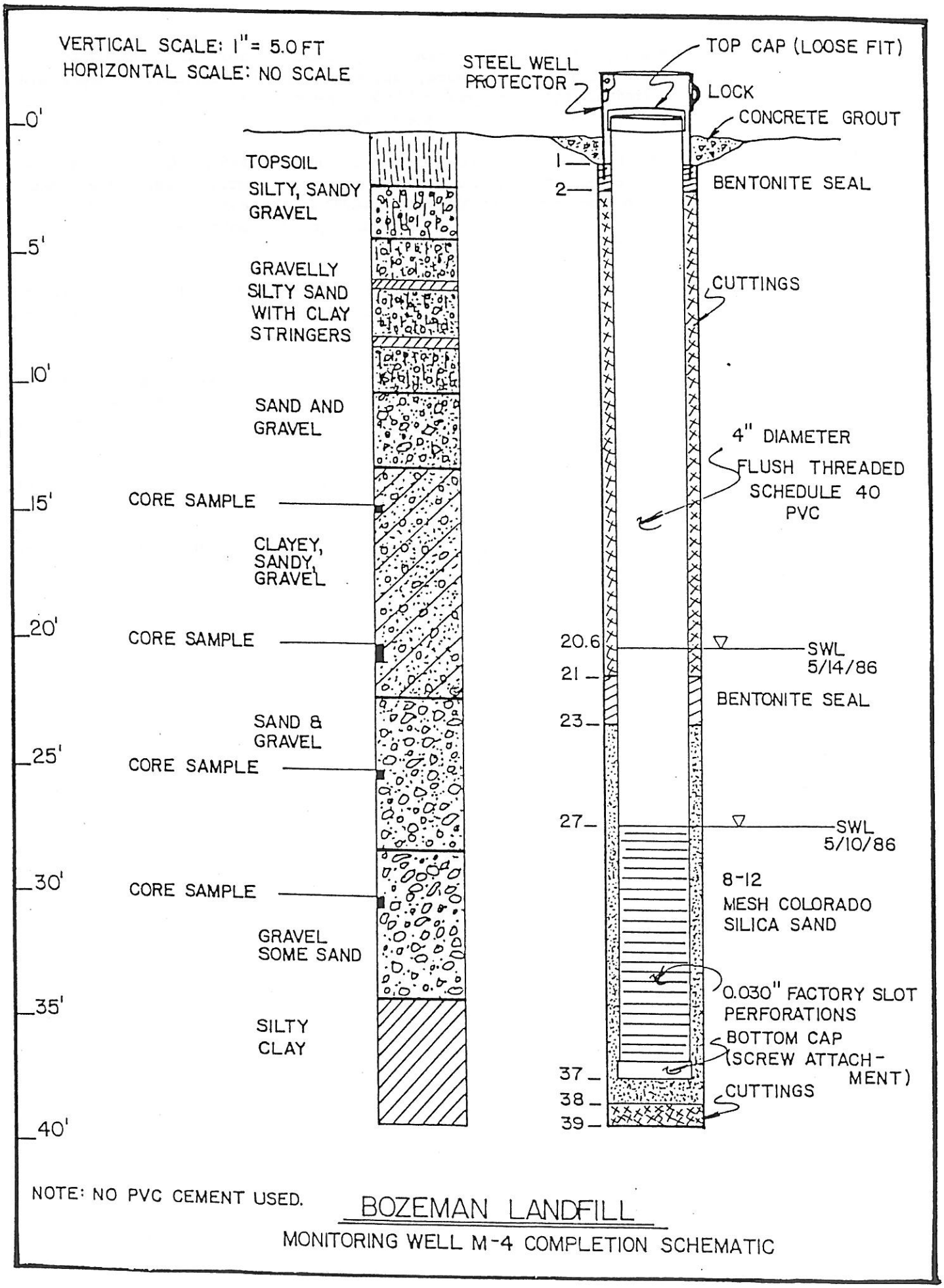
Well Annulus Completion Description: 4" Flush Threaded PVC; 0.030" Perforations from 27'-37'; Bottom Cap; 8-12 Mesh Colorado Silica Sand Pack 38'-23'; 1/4" Volclay Bentonite Pellets 23'-21'; Cuttings 21' to 2'; Bentonite Seal and Concrete Grout to Ground Surface Steel Well Protector with Lock.

Remarks:

DRILLING AND LITHOLOGIC LOG

From	To	DRILLING LOG Geological, Drilling, and Water Conditions and Sampling
0	2'	Topsoil; dark brown to black, silty-clayey loam; organics.
2'	4'	Silty sandy gravel; (70% gravel, 30% sand and silt); gravels moderately rounded, up to 1.5", smaller gravels are subangular to subrounded, gravels are limestone; poorly sorted, silt/sand matrix tan to orange.
4'	10'	Gravelly silty sand; (60% sand and silt, 40% gravel); less gravels than above, hard drilling, a few thin beds of orange to tan clay; light brown to red matrix.

10'	13'	Sand and gravel; (sand 50%, gravel 50%); occasional thin beds of reddish-orange clay 1-3", drills hard, approximately 5 feet/hour. Clasts are predominantly dark gray to black limestone, mostly carbonates, occasional quartz and chert grains, plenty of calcite.
13'	22'	Clayey sandy gravel, drills hard; core sample at 14.5', 100 blows/3" sample; core recovered limestone clast 1" diameter, matrix of sandy clay, orange tan, core sample at 20', 100 blows/8" sample, core - sandy gravel, little clay, clasts 1/4" to 1/2" limestone gravels, matrix - dark orange brown sand.
22'	28'	Sand and gravel (70% sand, 30% gravel) gravel up to 1", limestone gravels, medium to fine sand, poorly sorted subrounded, dark brown to orange, core sample at 25', 100 blows/3" sample.
28'	34'	Gravel; (80% gravel, 20% sand); gravel up to 2" diameter, dark gray limestone, medium to fine sand matrix, very hard drilling; caliche on clast surfaces, very little silt and clay. Core sample at 30', 100 blows/4" sample; recovered a few large gravels, no matrix.
34'	39'	Silty clay; tan to orange, fast easy drilling. Hole stays open, appears to make water at 33', clay sticks to drill tool.
		Bailed out hole with surge sand bailer before installation of PVC. 6" diameter threaded steel casing was used.



NOTE: NO PVC CEMENT USED.

BOZEMAN LANDFILL

MONITORING WELL M-4 COMPLETION SCHEMATIC

APPENDIX E

CHLORIDE CONCENTRATION DATA AND GRAPHS

CHLORIDE CONCENTRATIONS
TABLE E - 1

	7/81	5/82	11/82	5/83	6/83	11/83	5/84	11/84	5/85	11/85	5/86	8/87
MW-1	2.9	50.7	12.7	5	6.8	18	1	2.4	6.3		5	2
MW-2		33.8	20.5	65	11.5	68	16.97	17	29	14	7	10
MW-3	6.8	34.8	37.1	450	624	580	45.9	40	54	53	42	30
MW-4											21	15
LF-1										21	22	48
LF-2										25	27	23
LF-3										15	15	11
SHOP	6.8	7.2	4.9	5	9.7	9	1	2.4	4.4	4	5	2

	12/87	5/88	11/88	5/89	6/89	10/89	7/90
MW-1	1	3	2	4	1	2	6
MW-2	9	6	4.8	3.7	2.68	3.63	16
MW-3	28	26	28	23	17	24	23
MW-4	11	12	10	13	8	11	10
LF-1	17	18	17	19	17	17	24
LF-2	20	23	20	23	19	20	18
LF-3	10	12	9	10	8	8	8
SHOP	2	2	1	2	6	1	2

Note: Data gaps indicate well was not sampled or was not installed at that time.

FIGURE E-1
CHLORIDE CONCENTRATIONS

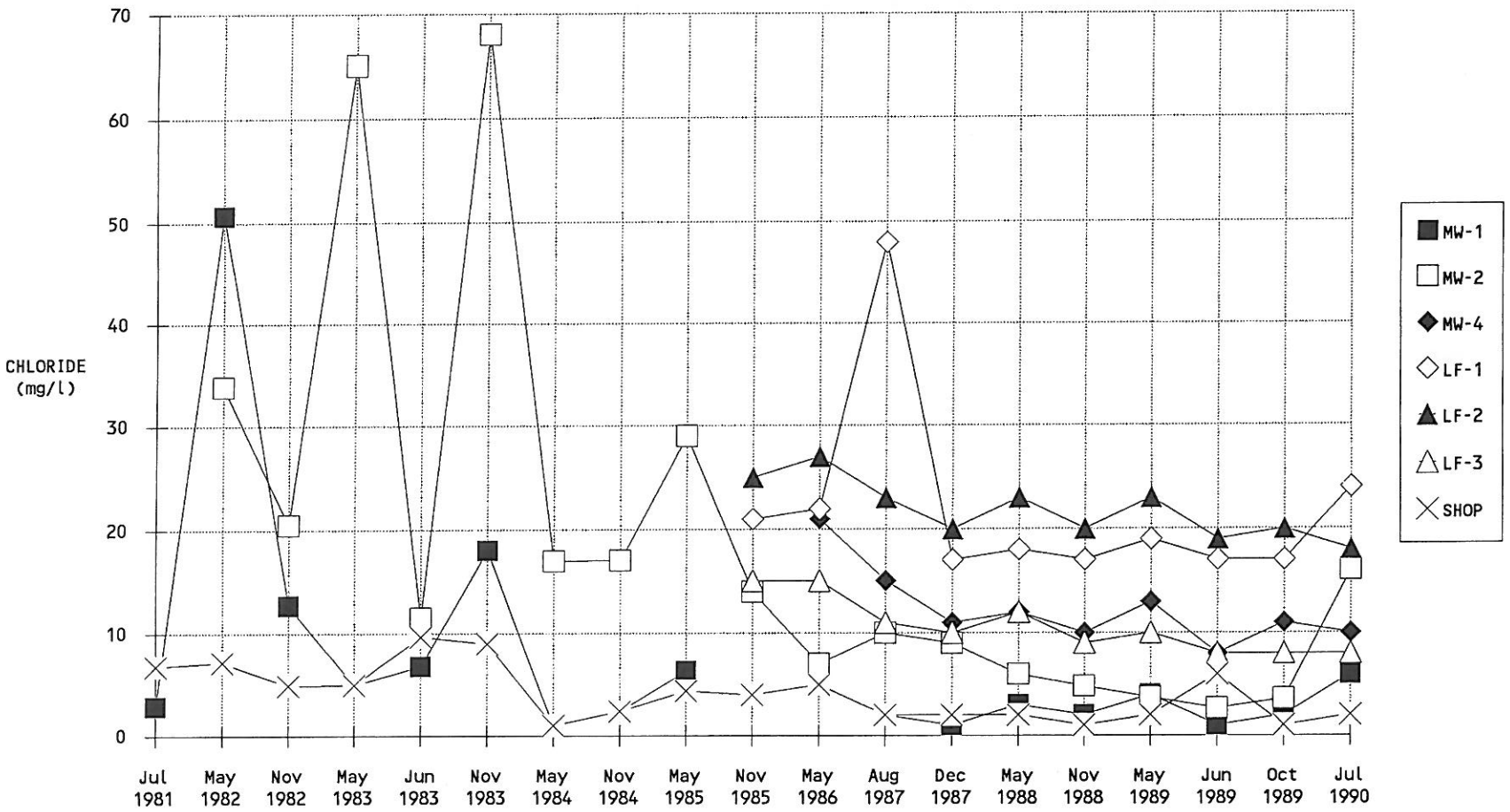
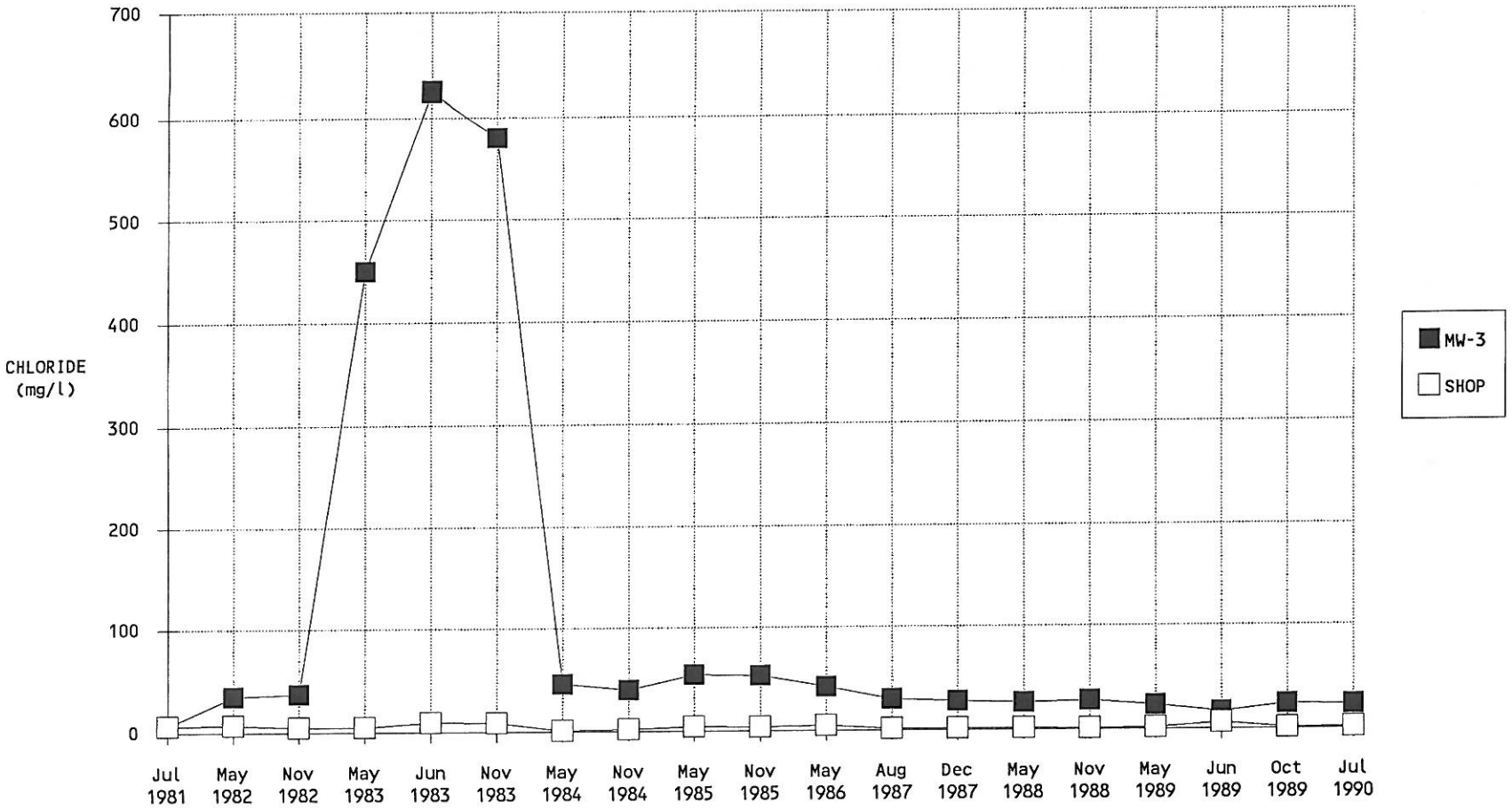


FIGURE E - 2
CHLORIDE CONCENTRATIONS



APPENDIX F

DRINKING WATER QUALITY STANDARDS

TABLE F-1

DRINKING WATER QUALITY STANDARDS - UNITED STATES

The U.S Environmental Protection Agency's National Primary Drinking Water Regulations and National Secondary Drinking Water Regulations are summarized in the following Tables:

National Primary Drinking Water Standards

Constituent	MCL mg/L
INORGANICS	
Arsenic (AS)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Cr)	0.05
Fluoride (F)	4.0
Lead (Pb)	0.05
Mercury (Hg)	0.002
Nitrate (as N)	10.0
Selenium (Se)	0.01
Silver (Ag)	0.05
MICROBIOLOGICALS	
Coliforms	1/100 mL
PHYSICAL CHARACTERISTICS	
Turbidity, NTU	1-5
ORGANICS	
2,4-D	0.1
2,4,5-TP Silvex	0.01
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
Total trihalomethanes	0.10
RADIONUCLIDES	
Beta particle and photon activity, mrem	4 (annual dose equivalent)
Gross alpha, pCi/L	15
Radium-226 and 228, pCi/L	5
VOLATILE ORGANIC CHEMICALS	
Benzene	0.005
Carbon tetrachloride	0.005
1,2-Dichloroethane	0.005
1,1-Dichloroethylene	0.007
1,1,1-Trichloroethane	0.20
para-Dichlorobenzene	0.075
Trichloroethylene	0.005
Vinyl chloride	0.002

TABLE F-1 (Continued)

DRINKING WATER QUALITY STANDARDS - UNITED STATES

NATIONAL SECONDARY DRINKING WATER STANDARDS

Constituent	SMCL Level (mg/L)
Chloride	250
Color, color units	15
Copper (Cu)	1
Corrosivity	Noncorrosive
Fluoride	2.0
Surfactants (MBAS)	0.5
Iron (Fe)	0.3
Manganese (Mn)	0.05
Odor, threshold odor number	3
pH, pH units	6.5-8.5
Sulfate (SO_4)	250
Total dissolved solids (TDS)	500
Zinc (Zn)	5.0

APPENDIX G

VELOCITY CALCULATIONS

VELOCITY CALCULATIONS

Bozeman Sanitary Landfill

Formula

$V = Q/nA = Ki/n$

V = average linear velocity
n = effective porosity
i = gradient

Assumed Values

Coarse sand

$n^1 = .39$
$K^2 = 150$ feet/day

Clay

$n^1 = .45$
$K^2 = .00066$ feet/day

Gradient

M-2 to LF-1

$i = 16.7/1015 = .016$

Velocity Calculations

Coarse sand

$V = 150(.016)/.39$
$= 6.15$ feet/day

Clay

$V = .00066(.016)/.45$
$= 2.13 \times 10^{-5}$ feet/day

1 Driscoll, 1987

2 Johnson, 1967