Basis & Background of the Septic Density Standard of the Highlands Water Protection and Planning Act Rule at N.J.A.C. 7:38-3.4

Introduction

This document provides a discussion of the considerations and analyses performed to determine septic densities for the Highlands Preservation Area. In adopting the Highlands Water Protection and Planning Act (HWPPA), the Legislature eliminated designated sewer service areas and any associated treatment works approvals where wastewater collection systems had not been installed by August 10, 2004. Consequently, most development proposed within the Highlands Preservation Area will need to utilize individual subsurface sewage disposal systems (ISSDSs), or septic systems, for wastewater management.

The HWPPA at N.J.S.A.13:20-32(e) directs that a septic system density standard must be established at a level to prevent the degradation of water quality, or to require the restoration of water quality, and to protect ecological uses from individual, secondary, and cumulative impacts, in consideration of deep aquifer recharge available for dilution. The septic system density standard was to be established in consideration of the antidegradation provisions of both the Surface Water Quality Standards (SWQS) at N.J.A.C. 7:9B-1.5(d)6(iii), and Stormwater Management rules at N.J.A.C. 7:8-5.5(h), that are applicable to Category One waters, and are to be applied to all Highlands open waters pursuant to subsection g. of section 34 of P.L.2004, c.120 (C.13:20-32). The Surface Water Quality Standards rules at N.J.A.C. 7:9B-1.5(d)6.iii. state that Category One Waters shall be protected from any measurable changes (including calculable or predicted changes) to the existing water quality. The Stormwater Management rules at N.J.A.C. 7:8-5.5(h) require the preservation of a 300-foot special water resource protection area (SWRPA) along all Category One waters.

To comply with the direction of the Legislature, the Department needed to determine the parameter(s) of concern, the existing quality of the groundwater with respect to the parameter(s) in the Highlands, the loading of the parameter(s) contributed by a typical septic system and the appropriate model to relate load to concentration in order to achieve no degradation of the water quality. In accordance with the HWPPA, the Department evaluated and selected a dilution model to relate load to concentration. Nitrate was selected as the indicator parameter because, of the constituents present in significant and predictable concentrations in septic system effluent, nitrate required the greatest dilution in order to attain ambient quality. To apply the model, values for the following model inputs were selected: an annual recharge rate representative of the Highlands region (9.8 inches per year); a number of persons per household unit representative of the region's population (4 persons per unit); the load of nitrate contributed per system (10 pounds per person per year); and target concentrations of nitrate. Two ambient nitrate concentration standards were selected, 0.21 mg/L for forest land use and 0.76 mg/L for mixed land use.

Applying these model inputs, the Department calculated two regional standards to be applied across the Highlands Preservation Area based on the land use. For forest land use, 88 acres per septic system are required. For mixed land use, 25 acres per septic system are required.

Model Selection

The HWPPA specifically mandates "consideration of deep aquifer recharge" in establishing the septic density standard, but does not provide any clarifying direction in this regard. There are several types of aquifers within the Highlands region, each classified by its geologic make-up that dictate the aquifer's ability to transmit and store quantities of water. Bedrock aquifers in the Preservation Area are predominantly crystalline, e.g., igneous and metamorphic rock such as gneiss, granite, schist and marble. Ground water is transmitted and stored in fractures, which may be enlarged due to chemical weathering. Carbonate and clastic bedrock aquifers comprise a much smaller percentage of area, but some are common in valleys. Carbonate aquifers are composed primarily of limestone and dolomite, while clastic aquifers are mostly slate, siltstone and sandstone. These latter aquifers also transmit and store water via fractures. Glacial aquifers are composed mostly of highly permeable glacial valley fill consisting of sand and gravel. Glacial aquifers can reach a thickness of 300 feet or more in places, but are typically less than 200 feet thick. They are bounded by less permeable bedrock valley walls and are well connected hydrologically to streams. Valley fill aquifers provide significant storage and yields of water. By far, the bulk of water withdrawals from wells in the New Jersey Highlands are from glacial aquifers, more so than from wells in all types of bedrock aquifers combined (USDA, 2002).

All of the Highlands aquifers receive recharge from precipitation onto the land surface that percolates downward into the aquifer. In the case of bedrock aquifers some of this percolating ground water may encounter impermeable bedrock layers, which divert the water into fractures or cause it to discharge to surface water. The water that enters the fracture network goes deeper into the aquifer and is available for ground water supply. The water that is diverted to streams is available as surface water supply. Eventually all of the deep ground water discharges to streams in the Highlands or adjacent areas.

It is extremely challenging to attempt to quantify the precise amount of water that is diverted to surface water from the shallow part of an aquifer versus that which enters deeper fractures. Stream base flow separation methods provide an assessment of the rate at which ground water discharges to surface water, but available methods do not permit the user to segregate what percentage of the discharge is derived from the shallow weathered zone versus what enters deep fractures that wells tend to penetrate. The problem is compounded by the fact that discharge to streams via shallow ground water pathways mixes in streams with water following deeper pathways through the aquifer to the stream.

The difference between "shallow" and "deep" aquifer recharge may not be significant in unconsolidated granular aquifers, such as the glacial sand and gravel aquifers and in carbonate aquifers. Most, and in many cases, all of the mixing and dilution of nitrate nitrogen from septic effluent occurs in and below the root zone in what is commonly referred to as the "shallow" zone, noting that the “shallow” zone can be as much as 100-feet deep or more. However, in consolidated rock aquifers, there may be a sharp contrast between the soil horizon(s) and rock, and significant partitioning of the ground water between “shallow” and “deep” aquifers is likely. This partitioning will vary both spatially and vertically as fractures close with depth, and cannot be quantified without detailed site studies.

The Department believes the correct interpretation of the HWPPA language is to use a conservative approach in estimating recharge available for dilution. Establishing such an approach required the Department to make two decisions: 1) determine the most appropriate and scientifically defensible methodology with which to estimate annual average recharge in the Highlands Region, and 2) determine the appropriate critical conditions under which to apply the model in order to be adequately protective.

There are approaches that have been used previously by the Department to estimate aquifer recharge. One method estimates the rate at which water enters the ground water system (ground water recharge), and the other estimates the rate at which water leaves the ground water system and enters surface water (base flow in streams). The ground water recharge method the Department uses currently is a ground water recharge model entitled New Jersey Geological Survey Report 32 (GSR-32), established in 1993 (Charles, *et al*). GSR-32 uses localized data for temperature, precipitation, and soil type to derive a soil moisture budget that estimates how much water that infiltrates the soil actually recharges the water table. Methods that estimate ground water recharge based on ground water discharge to surface water are known as base flow or hydrograph separation methods. These involve mathematical techniques to analyze stream flow to determine what part of stream flow comes from ground water. There are a number of these methodologies in practice, and each gives slightly different results for the same stream-flow data.

The context for method selection must be guided by the intent of the legislation, which is to protect and restore ground water and surface water quality. Therefore, regardless of the methodology chosen to estimate ground water recharge, it is necessary to establish a critical period of low flow to provide sufficient protection for the water resource. During extended dry periods, recharge is reduced and less available to dilute pollutants reaching the ground water. In turn, surface waters, which are sustained by base flow from ground water, are diminished and more susceptible to pollutant build-up and degradation. Therefore, it is reasonable to use data from an extended drought period or a statistically derived lower base flow period, such as the 7-day/10-year statistic frequently used in evaluating water resources impacts. The use of low recurrence intervals, such as the lowest daily, weekly, or monthly flows, are not representative of the long-term balances that are actually achieved. Short duration hydrologic events such as these are often immediately followed by normal periods that offset their effect in relatively short order. In the end, the Department determined that the drought of record in New Jersey, circa 1961-1966, provided the best fit.

Efficient mathematical models have already been developed that relate nitrate load to ground water concentration using dilution and a suite of geologic and atmospheric variables. These mass dilution models, driven in large part by the anticipated volume of recharge available for dilution, estimate the average land area required per disposal system to generate enough recharge to dilute that system's effluent to a target concentration. The Trela-Douglas nitrate dilution model (1978), updated or modified as needed by the program or entity utilizing it, has been used in New Jersey for over 20 years. It is employed by the Department in Realty Improvement Act reviews as well by the New Jersey Pinelands Commission to determine appropriate density. The New Jersey Geological Survey (NJGS) also developed a version called *A Recharge-based Nitrate-dilution Model for New Jersey* (Hoffman and Canace, 2004) for Water Quality Management Plan amendments.

The NJGS model was developed by coupling the Trela-Douglas nitrate-dilution model with the GSR-32 (Charles *et al*, 1993) ground water recharge model. GSR-32 determines ground water recharge rates subject to conditions specific to New Jersey, and is applicable only to New Jersey. It incorporates variations in land use, soil type, and a municipality-based climate factor that addresses regional variations for parameters such as rainfall and temperature, utilizing over 30 years of data. These and other factors assessed in unison estimate the rate of recharge for a given soil type in a given locale. GSR-32 is also the methodology used to calculate ground water recharge in accordance with the Stormwater Management Rules at N.J.A.C. 7:8-5.6(b)1. For complete details on *A Recharge-based Nitrate-dilution Model for New Jersey* methodology and assumptions, refer to A Recharge-Based Nitrate-Dilution Model for New Jersey: N.J. Geological Survey Open-File Report 04-1 (Hoffman and Canace, 2004).

Several modifications have recently been incorporated into *A Recharge-based Nitrate-dilution Model for New Jersey*. The first is a revision of climate factors that allow a smoother approximation of meteorological conditions across the state. The second is the use of climate factors based solely on the drought conditions of June 1961-August 1966, New Jersey's drought of record, in order to assess recharge during protracted drought conditions to represent a critical condition, as discussed above. The third is the replacement of the variable, model-selected impervious cover (IC) value, which is based on an estimate of a residential lot's percentage of IC as a function of lot size, with a chosen fixed value, in light of the maximum allowed IC of 3% pursuant to subsection h. of section 34 of P.L.2004, c.120 (C.13:20-32).

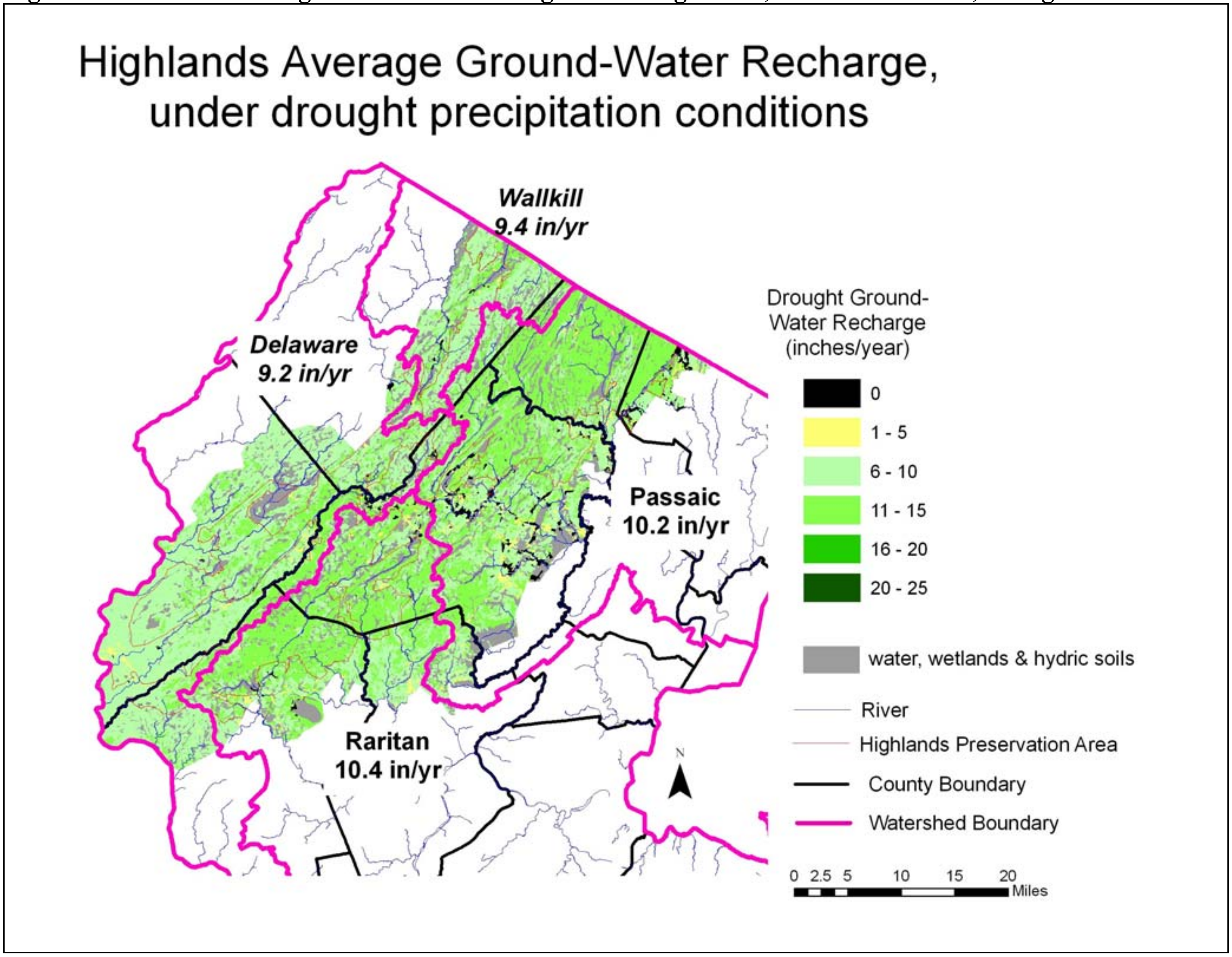
Using *A Recharge-based Nitrate-dilution Model for New Jersey* (Hoffman and Canace, 2004), the result for drought conditions was an area-weighted annual average recharge value of 9.8 inches per year (Table 1). Figure 1 illustrates the spatial variations due to differences in precipitation rates and soil attributes. As depicted, precipitation rates and subsequently recharge can vary throughout the Highlands Region. Generally, the higher elevations receive more precipitation than the lowlands, though this does not necessarily translate to the highest rates of recharge due to variations in soil type and land cover. A weighted average that accounted for these variations revealed that on a regional level, the differences in estimated recharge was not significant, exhibiting a range of 9.2 to 10.2 inches annually.

The second approach considered to assess recharge was base flow or hydrograph separation, which attempts to separate total stream flow into two unique components: 1) storm water runoff, which enters the stream by direct overland flow, and 2) base flow derived from water that infiltrates into the ground and discharges to the stream at a later time. Base flow is synonymous with the low flow of a stream, sustained by ground water inflow to the stream

Table 1. GSR-32 recharge estimates under drought conditions.

Basin	HUC 11 #	HUC 11 Name	Ground-Water Recharge (inches/yr)	Area-Weighted Basin Average
Wallkill	02020007010	Wallkill River (above road to Martins)	9.1	9.4
	02020007030	Wallkill River (below road to Martins)	8.8	
	02020007040	Pochuck Creek	9.8	
Passaic	02030103010	Passaic River Upper (above Pine Brook bridge)	9.8	10.2
	02030103020	Whippany River	8.8	
	02030103030	Rockaway River	9.8	
	02030103040	Passaic River (Pompton to Pine Brook)	8.3	
	02030103050	Pequannock River	10.9	
	02030103070	Wanaque River	11.5	
	02030103100	Ramapo River	10.4	
	02030103110	Pompton River	9.1	
	02030103140	Saddle River	8.6	
Raritan	02030105010	Raritan River SB (above Spruce Run)	10.7	10.4
	02030105020	Raritan River SB (Three Bridges to Spruce Run)	10.2	
	02030105040	Raritan River SB (NB to Three Bridges)	11.0	
	02030105050	Lamington River	10.5	
	02030105060	Raritan River NB (above Lamington)	10.4	
	02030105070	Raritan River NB (SB to Lamington)	7.7	
	02030105120	Raritan River Lower (Lawrence to Millstone)	8.9	
Delaware	02040105040	Paulins Kill (above Stillwater Village)	8.5	9.2
	02040105050	Paulins Kill (below Stillwater Village)	9.0	
	02040105060	Stony Brook/Delawanna Creek	9.2	
	02040105070	Pequest River (above/incl. Bear Swamp)	9.1	
	02040105080	Bear Creek	8.7	
	02040105090	Pequest River (below Bear Swamp)	9.7	
	02040105100	Beaver Brook	9.3	
	02040105110	Pophandusing Brook/Buckhorn Creek	8.8	
	02040105120	Lopatcong Creek	7.9	
	02040105140	Pohatcong Creek	8.9	
	02040105150	Musconetcong River (above Trout Brook)	9.5	
	02040105160	Musconetcong River (below/incl. Trout Brook)	9.8	
	02040105170	Hakihokake/Harihokake/Nishisakawick Creeks	9.2	
				$\bar{x}$ = **9.8**

Figure 1. Distribution of ground-water recharge in the Highlands, GSR-32 estimate, drought conditions.



channel. Base flow volumes change seasonally, but follow predictable trends that can be documented in a stream's annual hydrograph. Storm water runoff or overland flow, on the other hand, are increases in flow rates after precipitation events that are assumed to end within hours to days after the storm peak. Base flow can be considered a possible surrogate for recharge in that it represents the long-term "steady-state" of a region's water resources.

Generally, base flow separation techniques attempt to separate the stream flow hydrograph into separate components, including surface runoff and "ground water runoff." This is done using graphical techniques wherein the start of the ascending limb of the stream hydrograph is projected under the final peak in the stream flow curve for each precipitation event, based upon some time interval assumed to represent the duration of overland flow after each event. The sequence of these connecting lines produces a separate curve beneath the stream hydrograph, the base flow hydrograph. The area under the base flow hydrograph defines the base flow volume and rate. Numerous techniques have been developed, e.g., fixed interval, sliding interval, local minimum, etc. USGS used a sliding-interval methodology for their input into the 1996 New Jersey Statewide Water Supply Plan, however, they have since abandoned that method. Prior to the development of GSR-32, the NJGS utilized the Posten hydrograph separation method for their carrying capacity analyses. The Posten Method (1984) was selected for this analysis because, like GSR-32, it is based upon conditions specific to New Jersey. Posten’s analyses were focused in northern New Jersey geologic provinces, making it more appropriate for use in the Highlands and less likely to overestimate recharge. In addition, like GSR-32, the Posten Method has gone through an extensive peer-review process prior to publication.

NJGS programmed the algorithms mathematically reproducing the various steps of Posten's graphical technique of hydrograph separation. Posten's hydrograph separation method divides the stream flow hydrograph into base flow and overland flow components by projecting the recession limb of each storm event to a point below the peak of the following storm hydrograph. The sequence of points under each storm peak are joined by a line which defines the base-flow on each day between the points. In this manner, Posten attempts to account for variations of precipitation between storm events as well as seasonal variations within the annual hydrographs. Posten assessed over 30 years of data by developing a ranking system that organized all the available annual hydrographs based on annual flow volumes, so that a smaller sub-sample that represented the entire range of recorded flow conditions could be selected (n = 7-9). In other words, Posten selected a few examples of the drought, average and wet years, and then performed the actual hydrograph separations on this smaller subset. The NJGS program of the method can assess any chosen period of record or can be as limited or as comprehensive as the available data allow. For the selected critical condition, flow data from USGS gauging stations in the Highlands for the New Jersey drought of record were analyzed.

The USGS gauging stations selected were based on the following criteria (Figure 2):

(1) The majority of their watershed derives from the Highlands Preservation and Planning areas.
(2) They generally lack significant control of their flow (e.g., manmade impoundments).
(3) The hydrogeology of the watershed does not give rise to significant questions about the presence of ground-water underflow.

The result of the base flow separation analysis was an average annual recharge value of 10.2 inches/year for the drought of record (Table 2). This value is highly supportive of the GSR-32 result. The Department selected 9.8 inches/year as the regional annual recharge rate for the Highlands Preservation Area because it is the more conservative number.

Figure 2. Location of U.S. Geological Survey stream gauging stations in the Highland Region.

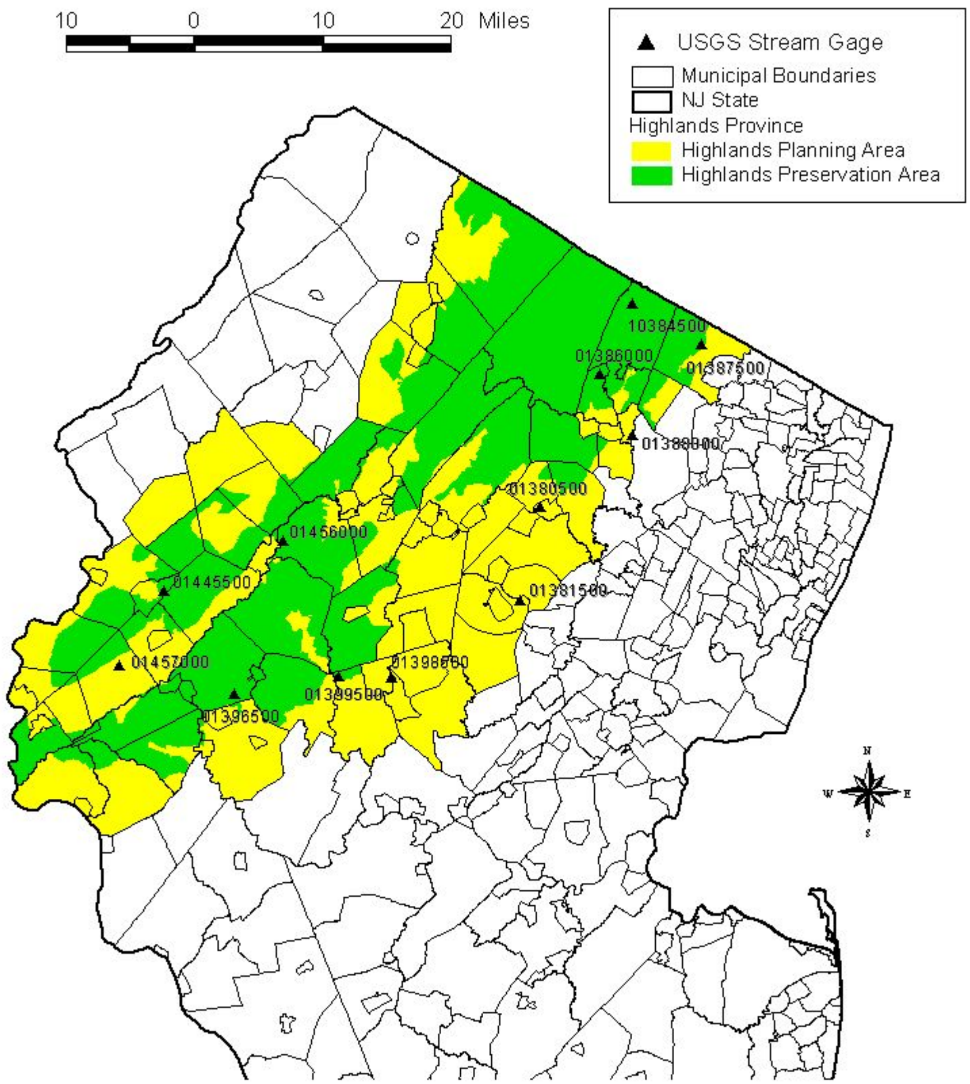


Table 2. Baseflow estimates at selected stream gages in Highlands basins using Posten (1984) method.

USGS Stream Gage		Watershed Area (sq. mi.)	Period of Record	Drought Baseflow (in./yr.)
USGS #	**Name**			
01399500	Lamington (Black) River near Pottersville	32.8	June/1960 – August/1966	10.4
01457000	Musconetcong River Near Bloomsbury	141.0		11.3
01456000	Musconetcong R. Near Hackettstown	68.9		10.8
01398500	North Branch Raritan River near Far Hills	26.2		9.8
01445500	Pequest River At Pequest	106.0		9.0
01387500	Ramapo River near Mahwah	120.0		11.3
01388000	Ramapo River at Pompton Lakes	160.0		7.7
01384500	Ringwood Creek near Wanaque	19.1		10.2
01380500	Rockaway River above Boonton Reservoir	116.0		10.9
01396500	S.Branch Raritan River near High Bridge	65.3		11.3
01386000	West Brook (Wanaque River Basin)	11.8		11.1
01381500	Whippany River at Morristown	29.4		10.3
Area-weighted mean recharge rate				**10.2**

* NJGS had previously used the Posten Method program to assess drought conditions using this slightly expanded period of drought for the 1996 New Jersey Statewide Water Supply Plan.

Population Density

To calculate pollutant loading from septic systems, it is necessary to establish a number of input variables, including the number of persons per dwelling unit served by a septic system. To establish a household occupation rate, the Department examined the latest U.S. census data to determine a representative residential density (U.S. Census Bureau data can be accessed at www.census.gov). Based on the most recent data available, the national average for household size is 2.7 people (U.S. Census Bureau, 2005). This value represents an average of all areas and housing types. Considering only those New Jersey counties relevant to the Highlands Region, e.g., Bergen, Hunterdon, Morris, Passaic, Somerset, Sussex, and Warren, the average household size is 2.8 people (U.S. Census Bureau, 2005). None of these counties lie wholly within the Highlands region, and some contain portions that are highly urbanized while others have large sections of agricultural and rural areas. Relying on the county data alone may result in a skewed average household size; however, data for each individual municipality is not available. Of the 45 municipalities that lie at least partly within the Highlands Preservation Area, 20 have individual data available either as a municipality or as a Census Designated Place (CDP). A CDP is an area identified by the U.S. Census Bureau for statistical reporting. It is a recognized concentration of population but one that is not legally incorporated under the laws of the state in which they are located, such as an urbanized area that extends beyond the boundary of an incorporated municipality. CDP boundaries may change from one census to the next to reflect changes in settlement patterns. The 20 applicable localities within the Highlands Preservation Area are shown in Table 3. The range of average household size is 2.2 to 3.1 persons per household, with an overall mean of 2.7.

Table 3. 2000 Census Data available for Municipalities and CDPs* of the Highlands Preservation Area.

Township or Munici-pality	Total # of house-holds	Average # of people/ household	Percentage of Households with Specified Occupancy Rate							
			Number of people per home							
			1	2	3	4	5	6	7 or more	4 or above
West Milford CDP	9,235	2.86	16.7%	32.1%	19.7%	19.0%	8.9%	2.7%	0.9%	**31.5%**
Vernon Valley CDP	553	3.14	7.8%	32.9%	19.2%	26.2%	9.2%	4.3%	0.4%	**40.1%**
Ringwood	4,091	3.03	12.1%	31.6%	20.5%	22.1%	9.7%	2.5%	1.4%	**35.7%**
Ogdensburg	881	2.99	16.6%	26.9%	18.2%	22.9%	10.9%	3.5%	1.0%	**38.3%**
Blooming-dale	2,842	2.68	21.9%	32.1%	20.2%	15.9%	7.1%	2.1%	0.7%	**25.8%**
Kinnelon	3,060	3.06	9.3%	32.7%	18.8%	24.5%	10.9%	3.1%	0.7%	**39.2%**
Oakland	4,263	2.92	12.6%	33.4%	20.6%	22.1%	8.6%	2.2%	0.5%	**33.4%**
Rockaway	2,449	2.64	23.6%	31.3%	18.1%	16.5%	7.4%	1.9%	1.1%	**26.9%**
Wanaque	3,447	2.98	16.6%	30.1%	20.9%	20.5%	7.5%	2.2%	2.2%	**32.4%**
Allamuchy-Valley CDP	1,405	2.21	29.9%	42.8%	11.3%	10.7%	3.1%	1.0%	1.2%	**16.0%**
Boonton Town	3,275	2.59	26.2%	33.5%	16.6%	13.0%	6.5%	1.9%	2.2%	**23.6%**
Chester	604	2.71	23.5%	32.8%	13.7%	18.2%	8.4%	2.3%	1.0%	**29.9%**
Hopatcong	5,660	2.82	18.4%	30.4%	19.2%	20.2%	8.6%	2.2%	1.1%	**32.1%**
Washington Twp. CDP	3,220	2.77	14.5%	36.0%	19.9%	19.2%	7.7%	2.0%	0.6%	**29.5%**
Califon	402	2.62	21.1%	33.8%	14.9%	18.2%	11.2%	0.7%	0%	**30.1%**
Franklin	1,911	2.71	24.5%	31.0%	17.4%	15.5%	7.6%	2.3%	1.6%	**27.0%**
Hampton	554	2.79	27.3%	28.3%	17.5%	17.6%	7.7%	2.9%	0%	**28.2%**
Lebanon	457	2.33	32.6%	32.4%	14.9%	13.8%	4.6%	1.8%	0%	**20.2%**
Oxford CDP	894	2.56	26.2%	29.3%	17.7%	16.0%	8.1%	1.6%	1.2%	**26.9%**
Glen Gardner	805	2.36	33.5%	28.9%	15.8%	15.9%	4.2%	1.0%	0.6%	**21.7%**
	Σ=50,008									
Weighted Average of All households with 4 or more persons:										**30.6%**

* CDP = Census Designated Place

The municipal and CDP data were further analyzed to calculate the distribution of household size, e.g., 1-person, 2-person, up to 7 or more, relative to the total number of households per municipality and CDP. As shown in Table 3, the percent of the residential population living in households of 4 or more is as high as 40.1 % within the municipalities and CDPs examined. The weighted average among total households is 30.6%. In addition, the majority of the households that contain 4 or more people are those that house 4 people. Therefore, a representative occupancy rate of 4 persons per household was used to establish a conservative loading per unit.

Selection of Parameter(s)

Using a dilution analysis to determine a density that will comport with antidegradation goals articulated in the HWPPA required consideration of the pollutants that are contained in septic effluent. ISSDSs discharge constituents including nutrients, bacteria, dissolved solids and organic compounds (USEPA, 2002). Some constituents are present in significant and predictable amounts while others are present in minute and/or variable amounts based on user behavior. Some constituents are significantly attenuated by the action of microorganisms and chemical reactions in the soil through which the effluent travels. Others, such as nitrate and dissolved solids like sodium and chloride, are attenuated primarily by dilution. Nitrate, phosphorus and total dissolved solids (TDS) were selected as parameters of concern to test for use in the model because they are present in septic effluent in relatively large and predictable amounts (Tables 4 and 5).

Table 4. Table [3-18] from *USEPA: Onsite Wastewater Treatment Systems Manual* (2002); Case study: septic tank effluent and soil water quality[a].

Parameter (units)	Statistics	Septic tank effluent quality	Soil water quality[b] at 0.6 meter	Soil water quality[b] at 1.2 meters
BOD (mg/L)	Mean Range # samples	93.5 46-156 11	<1 <1 6	<1 <1 6
TOC (mg/L)	Mean Range # samples	47.4 31-68 	7.8 3.7-17.0 34	8.0 3.1-25.0 33
TKN (mg/L)	Mean Range # samples	44.2 19-53 11	0.77 0.40-1.40 35	0.77 0.25-2.10 33
NO_3-N (mg/L)	Mean Range # samples	0.04 0.01-0.16 11	21.6 1.7-39.0 35	13.0 2.0-29.0 32
TP (mg/L)	Mean Range # samples	8.6 7.2-17.0 11	0.40 0.01-3.8 35	0.18 0.02-1.80 33
TDS (mg/L)	Mean Range # samples	497 354-610 11	448 184-620 34	355 200-592 32
Cl (mg/L)	Mean Range # samples	70 37-110 11	41 9-65 34	29 9-49 31
F.coli (log # per 100 mL)	Mean Range # samples	4.57 3.6-5.4 11	nd[c] <1 24	nd <1 21
F. strep (log # per 100 mL)	Mean Range # samples	3.60 1.9-5.3 11	nd <1 23	nd <1 20

a The soil matrix consisted of a fine sand; the wastewater loading rate was 3.1 cm per day over 9 months.
TOC = total organic carbon; TKN = total Kjeldahl nitrogen; TDS = total dissolved solids; Cl = chlorides; F.coli = fecal coliforms; F.strep = fecal streptococci.

b Soil water quality measured in pan lysimeters at unsaturated soil depths of 2 feet (0.6 meter) and 4 feet (1.2 meters).

c nd = none detected.

Source: Adapted from Anderson, *et al*. 1994.

Table 5. Table [3-19] from *USEPA: Onsite Wastewater Treatment Systems Manual* (2002); Wastewater constituents of concern and representative concentrations in the effluent of various treatment units.

Constituents of concern	Example direct or indirect measures (Units)	Tank-based treatment unit effluent concentrations					SWIS3 percolate into ground water at 3-5 ft depth (% removal)
		Domestic STE1	Domestic STE with N-removal recycle2	Aerobic unit effluent	Sand filter effluent	Foam or textile filter effluent	
Oxygen demand	BOD_5 (mg/L)	140-200	80-120	5-50	2-15	5-15	>90%
Particulate solids	TSS (mg/L)	50-100	50-80	5-100	5-20	5-10	>90%
Nitrogen	Total N (mg N/L)	40-100	10-30	25-60	10-50	30-60	10-20%
Phosphorus	Total P (mg P/L)	5-15	5-15	4-10	<1-10[3]	5-15[3]	0-100%
Bacteria (e.g., *Clostridium perfrigens, Salmonella, Shigella*)	Fecal coliform (organisms per 100 mL)	10^6-10^8	10^6-10^8	10^3-10^4	10^1-10^3	10^1-10^3	>99.99%
Virus (e.g., hepatitis, polio, echo, coxsackie, coliphage)	Specific virus (pfu/mL)	0-10^5 (episodically present at high levels)	0-10^5 (episodically present at high levels)	0-10^5 (episodically present at high levels)	0-10^5 (episodically present at high levels)	0-10^5 (episodically present at high levels)	>99.9%
Organic chemicals (e.g., solvents, petro-chemicals, pesticides)	Specific organics or totals (μg/L)	0 to trace levels (?)	0 to trace levels (?)	0 to trace levels (?)	0 to trace levels (?)	0 to trace levels (?)	>99%
Heavy metals (e.g., Pb, Cu, Ag, Hg)	Individual metals (μg/L)	0 to trace levels	0 to trace levels	0 to trace levels	0 to trace levels	0 to trace levels	>99%

1 Septic tank effluent (STE) concentrations given are for domestic wastewater. However, restaurant STE is markedly higher particularly in BOD_5, COD, and suspended solids while concentrations in graywater STE are noticeably lower in total nitrogen.

2 N-removal accomplished by recycling STE through a packed bed for nitrification with discharge into the influent end of the septic tank for denitrification.

3 P-removal by adsorption/precipitation is highly dependent on media capacity, P loading, and system operation.

Source: Siegrist, 2001 (after Siegrist, *et al.* 2000).

An initial screening was performed to determine which of the above three parameters would require the most acreage to achieve dilution to ambient quality. Simplistic versions of *A Recharge-based Nitrate-dilution Model for New Jersey* dilution-model were developed for each parameter in order to assess and compare them. These models only provide the acreage required to dilute a proposed loading of nitrate, phosphorus, and TDS—they do not account for fluctuations in climate, soil type, and impervious cover. However, they quickly and effectively reflect the most limiting parameter that would be selected as the basis for calculating densities that ensure a protective approach. Values for both the input and target concentrations for each constituent were derived as follows, and entered into the appropriate model with the values for recharge and population density detailed previously.

Nitrate

The annual loading rate (input concentration) determined for nitrate is 10 pounds per person. This value is well established in New Jersey and is consistent with the *USEPA Onsite Wastewater Treatment Systems Manual* (2002). For target concentrations the chosen values were 0.21 mg/L nitrate for forested sites (*pristine*) and 0.76 mg/L for developed and/or non-forested sites (*mixed land use*). These target concentrations for nitrates will be explained fully in the following section: *Nitrate Target Concentration*. The preliminary model results are shown in Figures 3(a) and (b).

Figure 3(a).

Nitrate		
parameter	*value*	*units*
population density:	**4**	people/home
human nitrate loading rate	**10.0**	pounds/person/year
target:	**0.21**	mg/l
avg. lot size:	**85.9**	acres/home

Figure 3(b).

Nitrate		
parameter	*value*	*units*
population density:	**4**	people/home
human nitrate loading rate	**10.0**	pounds/person/year
target:	**0.76**	mg/l
avg. lot size:	**23.7**	acres/home

Phosphorus

Phosphorus is modified significantly by travel through soil, and concentrations from effluent are reduced drastically within just the first few feet of contact with soils (USEPA, 2002). Phosphorus compounds adsorb to, in large part, iron and aluminum minerals and in a series of chemical reactions form precipitate compounds that become part of the soil profile. After filtration by two feet of soil, total phosphorous concentration can be reduced by 22.4% to as much as 99.9%, dependent upon soil characteristics, oxidation-reduction potential, and pH. After four feet of soil filtration, concentrations are further attenuated (Table 4). Though the capacity for the soil to retain phosphorous is not limitless, predicting its effects on ground water is difficult to ascertain with any certainty.

To select an input concentration for use in the dilution model, the soil attenuation effect must be considered. Though the mean value of total phosphorus in septic effluent is listed as 8.6 mg/L in the above EPA reference, this value was adjusted to the mean concentration recorded at 2-feet (0.40 mg/L) and 4-feet (0.18 mg/L) to represent a more realistic input for dilution. These water-soluble concentrations will also likely be further attenuated with depth, beyond the dilution effect, because iron and aluminum exist at high levels in the deeper soils and even in the aquifer itself.

To select an appropriate target concentration, the sources considered were available ambient concentrations, the Surface Water Quality Standards at N.J.A.C. 7:9B-1.14(c), and target concentrations proposed in numerous Total Maximum Daily Loads (TMDLs) developed by the Department and approved by EPA (Table 6). The most restrictive concentration target is the ambient concentration, $\leq$ 0.01 mg/L. Using 0.01 mg/L as the target concentration for phosphorus resulted in considerably less acreage required than that for nitrate dilution (Figures 4(a) and (b)).

Table 6. Representative values for phosphorus concentration targets.

Reference Source	Geologic Province	Type of sample	No. of samples	Minimum (mg/L)	Median (mg/L)	Maximum (mg/L)
Serfes, 2004	Highlands	Ground water	45	<0.01	<0.01	0.09
Serfes, 2004	Highlands	Ground water	26	<0.01	0.02	0.04
NJ-SWQS	State-wide	Lakes, ponds, reservoirs	---			0.05
NJ-SWQS	State-wide	Streams	---			0.1
USGS/NWIS	Highlands	Ground water	5-8		0.01-0.015	

Figure 4(a). Results using Total P input of 0.4 mg/L and target standard of 0.01 mg/L.

Phosphorous		
parameter	*value*	*units*
population density:	**4**	people/home
water use rate	**75**	gpd/person
input concentration	**0.4**	mg/l
target:	**0.01**	mg/l
avg lot size	**16.5**	acres/home

4(b). Results using Total P input of 0.18 mg/L and target standard of 0.01 mg/L.

Phosphorous		
parameter	*value*	*units*
population density:	**4**	people/home
water use rate	**75**	gpd/person
input concentration	**0.18**	mg/l
target:	**0.01**	mg/l
avg lot size	**7.4**	acres/home

<u>Total Dissolved Solids</u>

Two values for the input TDS concentration were tested: the mean concentration for TDS in septic effluent referenced by EPA in Table 4 (497 mg/L) and the highest concentration recorded in the same case study (620 mg/L). For the concentration target, the Department considered two assessments of existing water quality. The first is a recent NJ Geological Survey report that summarizes ground water quality in the Highlands of New Jersey (Serfes, 2004). This report establishes baseline water quality in order to evaluate potential water quality problems. Based on results from 44 water samples from noncarbonate bedrock of northern NJ, the median TDS concentration is 135 mg/L. A second model run was performed using a lower target concentration of 117 mg/L. This value was derived using the mean specific conductance value (Table 8; expressed as µmhos/cm at 25ºC) for 7 Highlands wells that represent "pristine" conditions. The mean specific conductance value of 167 was multiplied by 0.7 to convert to TDS in mg/L (Linsley and Franzini, 1979). The results of these analyses are illustrated in Figures 5(a)-(d). As the results indicate, TDS is diluted and attenuated much more readily than both nitrate and phosphorus.

Figure 5(a) Results using TDS input of 497 mg/L and target standard of 135 mg/L.

TDS		
parameter	*value*	*units*
population density:	**4**	people/home
water use rate	**75**	gpd/person
input concentration	**497**	mg/l
target:	**135**	mg/l
avg lot size	**1.5**	acres/home

5(b) Results using TDS input of 497 mg/L and target standard of 117 mg/L.

TDS		
parameter	*value*	*units*
population density:	**4**	people/home
water use rate	**75**	gpd/person
input concentration	**497**	mg/l
target:	**117**	mg/l
avg lot size	**1.8**	acres/home

5(c) Results using TDS input of 620 mg/L and target standard of 135 mg/L.

TDS		
parameter	*value*	*units*
population density:	**4**	people/home
water use rate	**75**	gpd/person
input concentration	**620**	mg/l
target:	**135**	mg/l
avg lot size	**1.9**	acres/home

5(d) Results using TDS input of 620 mg/L and target standard of 117 mg/L.

TDS		
parameter	*value*	*units*
population density:	**4**	people/home
water use rate	**75**	gpd/person
input concentration	**620**	mg/l
target:	**117**	mg/l
avg lot size	**2.2**	acres/home

Discussion

As the graphics clearly illustrate, nitrate requires the greatest acreage to dilute effectively. In order to "protect from any measurable changes…to the existing water quality," establishing the septic density in terms of nitrate will concurrently protect from phosphorus and TDS as well, and by extrapolation to other minor effluent constituents also.

The Department considered the effect of using advanced technologies that can reduce the normal nitrate loads from septic effluent. This technology does exist and is desirable, but such alternative designs may not reduce all constituents proportionally. Therefore, it was determined to be inappropriate to allow an increase in septic density based on the use of technologies that are designed to reduce nitrate.

Nitrate Target Concentration

In light of the direction in the HWPPA to select a septic density that would not degrade water quality, the Department considered two land use scenarios, recognizing that the underlying ground water would have different ambient qualities depending on the presence/absence of anthropogenic inputs. The Department performed numerous exercises with available data and referred to numerous sources to assess ambient nitrate concentration specific to two land cover designations: forested and mixed land use. The first analysis was performed with the assistance of USGS staff and software. Water quality data for all New Jersey wells in the USGS QWDATA database (part of the National Water Information System/NWIS) was retrieved during Spring of 2005. All wells in confined units were deleted as they are not expected to have impacts from localized surface activities. A USGS program (Weedpoint) then sorted and selected the maximum number of wells without overlapping 500-meter buffers (n = 1315). Where wells were sampled at multiple depths, the shallowest sampling depth was automatically selected and/or, the most recent data record was selected. A grid was created that encompasses the Highlands Region based on longitude/latitude, because the USGS database records station locations in this manner. The ranges of coordinates used were latitude: 40º 32'00"– 41º 17'00" and longitude: 74º 06'00"– 75º 12'00" (Figure 6). Nitrate concentrations (expressed as nitrite and nitrate) for each well within that grid were then compiled (n = 514), resulting in a median concentration of 1.1 mg/L. Median concentration was used instead of mean concentration because of the effect of outliers that could skew the mean. In order to focus in more closely on the Highlands region, a second exercise was performed with the original grid further refined into 5 smaller sub-sections using tighter coordinates (Table 7). This resulted in 369 individual well data points and a median concentration of 1.0 mg/L nitrate and nitrite (see Appendix A for USGS station identification numbers and data).

Table 7. Set of latitude/longitude grids to represent Highlands area in order to assess nitrate levels.

Grid #	N-Latitude	S-Latitude	W-Longitude	E-Longitude
1	41º 17' 00"	41º 09' 00"	74º 33' 00"	74º 15' 00"
2	41º 09' 01"	41º 00' 00"	74º 40' 00"	74º 10' 00"
3	41º 00' 01"	40º 50' 00"	75º 00' 00"	74º 20' 00"
4	40º 50' 01"	40º 37' 00"	75º 00' 00"	74º 29' 00"
5	40º 50' 01"	40º 32' 00"	75º 10' 00"	75º 00' 01"

In a second analysis, all of the data for nitrate and nitrite available as of May 12, 2005 was downloaded from the USGS QWDATA database. For this effort, all nitrate and nitrite records for each well were compiled with no sorting or filtering, resulting in 633 data points from 388 wells within the 5 smaller grids. To address the potential of a skewed distribution due to unrepresentative outliers, the 95th percentile was chosen to delimit the appropriate data set. The 95th percentile high value was determined to be 3.6 mg/L nitrate and nitrite, e.g., 602 of the 633 data points were measured between 0.03 and 3.6 mg/L nitrate and nitrite. The mean concentration for these 602 data points was calculated as 0.8 mg/L of nitrate and nitrite.

Other peer-reviewed research sources also estimate ambient nitrate concentration for groundwater in the Highlands region within a comparable range, e.g., 1.15 mg/L (Hoffman and Canace, 2004), and <1.0 mg/L (Nicholson, 1996). Another recent NJ Geological Survey report aimed at establishing baseline water quality summarizes ground water quality in the New Jersey Highlands (Serfes, 2004). According to this study, based on results from 45 water samples from noncarbonate bedrock of northern New Jersey, the median ambient nitrate value (expressed as N) is 0.76 mg/L. Considering the results of all these analyses, the most conservative value of 0.76 mg/L was chosen as the nitrate target for mixed land uses.

To determine the nitrate target for forested lands, the Department applied the initial USGS analysis detailed above. Once the USGS program *Weedpoint* selected wells within the broad, Highlands grid without overlapping 500-meter buffers (n = 514), GIS was then utilized to designate land use/land cover within these 500-meter buffers based on Level I Anderson classifications: urban, forest, wetlands, barren, agriculture, and water.

To assess nitrate levels under conditions that best represent *pristine* in contemporary terms, the monitored wells were then selected based on the 500-meter buffer containing equal to or greater than 90% forest + wetlands + water, e.g., less than 10% urban, agricultural, or barren land use. A total of 14 monitored wells fit these criteria, 2 of which did not monitor for nitrates. Of the 12 remaining wells, the location of each was pinpointed using their latitude/longitude coordinates. Five of the wells fell outside the Highlands geologic province, e.g., both the Planning and Preservation areas and were thus removed from the sample set. Due to the size of the data set, the actual distribution profile is uncertain. Several values are grouped in each tail of the data set, with no values exceeding the 95 percent confidence interval of the distribution. The data present an average value of 0.21 mg/l nitrate + nitrite (Table 8).

Figure 6. Latitude/Longitude "Grids" used for retrieval of NO_3/NO_2 data from NWIS. Bolded boundary delineates the original, broad grid. Red boundaries delineate 5 refined sub-sections. Stream gauge data from New York is automatically exempt from a New Jersey data search.

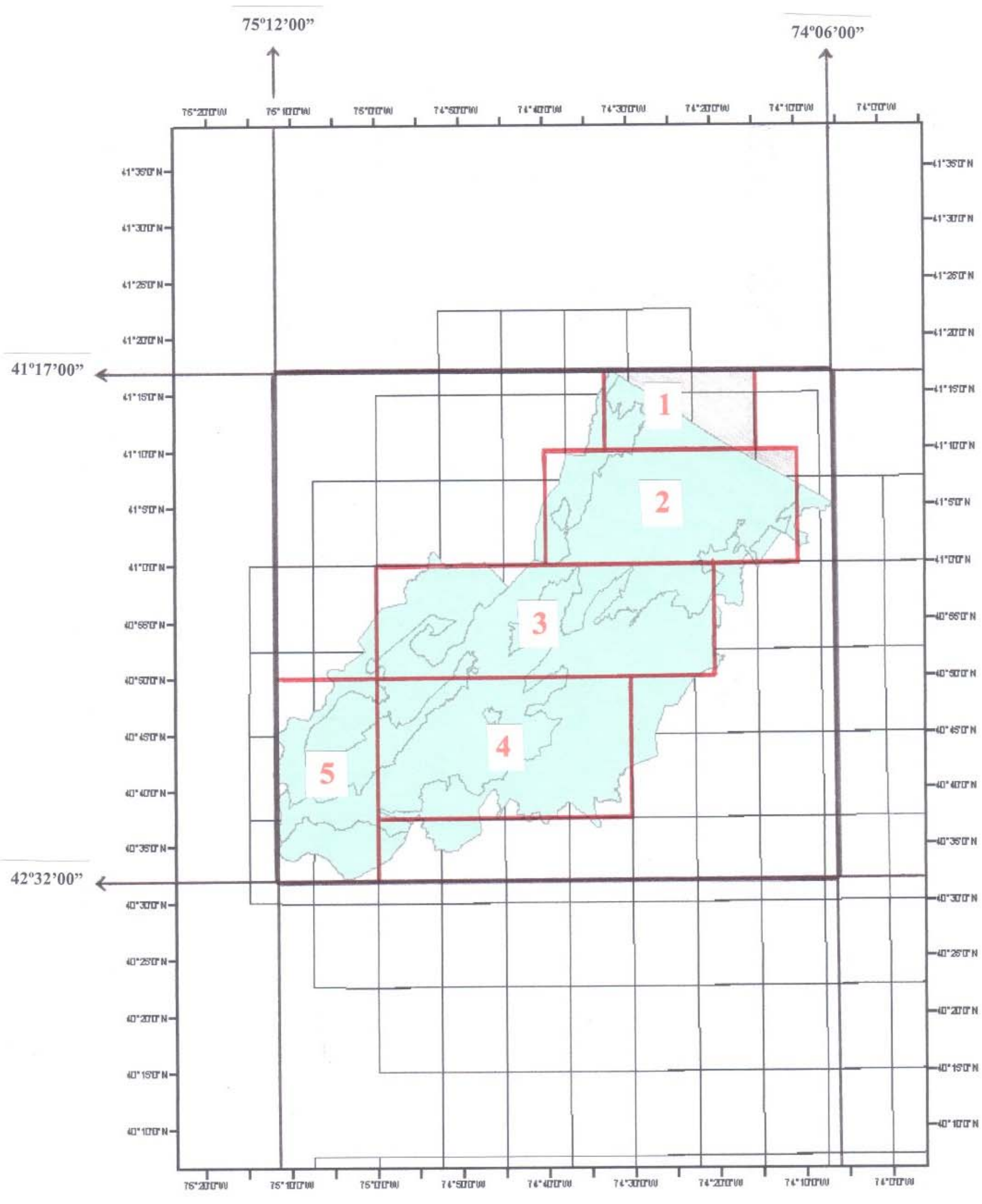


Table 8. USGS ground water wells in Highlands under *pristine* conditions.

USGS Station ID #	Latitude (º -'-")	Longitude (º -'-")	Specific Conductance (µmhos/cm at 25ºC)	NO3 + NO2-N (mg/L)	Forest + Water + Wetlands (% of 500*m* buffer)
404553074330001	40-45-44	74-33-05	169	0.4	0.925
411020074192701	41-09-33	74-19-45	176	0.1	0.907
404934074385901	40-49-34	74-38-59	140	0.3	0.999
405913074275301	40-59-18	74-26-51	167	0.1	0.947
405154074585701	40-51-54	74-58-57	207	0.03	0.929
405647074453401	40-56-47.42	74-45-34.18	247	0.41	0.915
410344074141601	41-03-44	74-14-16	61	0.1	0.976

Although 7 data points is a decidedly small sample size, these sites are among the few monitored and able to represent what ambient ground water conditions in the New Jersey Highlands can be under the best contemporary conditions possible. Concentrations in surface water were also evaluated. A Highlands reference stream used to assess background concentrations by the NJDEP/USGS Cooperative Network (Double Kill at Wawayanda) records a maximum concentration of 0.17 mg/L nitrate and nitrite out of 20 samples collected from 1997-2002. In addition, USEPA's *Ambient Water Quality Criteria Recommendations* (2001) for rivers and streams was consulted. This guidance manual was developed to suggest water quality criteria for nutrients to represent reference conditions for four major types of waterbodies: lakes and reservoirs, rivers and streams, estuaries and coastal waters, and wetlands by ecoregion. Data records for rivers and streams are among the most complete and comprehensive, and thought to be most representative for the purposes of this rule. Fourteen major ecoregions were delineated across the United States based on geology, land use, ecosystem type, and nutrient conditions. Each ecoregion was then further subdivided based on climate, vegetative cover, topography, and other ecological information pertaining to these sub-ecoregions (Omernik, 1999). Sub-ecoregion 58, the Northeastern Highlands, includes the New Jersey/New York Highlands, as well as portions of Pennsylvania and states of the New England Highlands: Connecticut, Massachusetts, Vermont, New Hampshire, and Maine.

The EPA manual describes two ways of establishing a reference condition: 1) choose the upper 25^{th} percentile (75^{th} percentile) of a reference population of streams, or; 2) when reference streams are not identified, determine the lower 25^{th} percentile of the population of all streams within a region (USEPA, 2001). Data analyses to date indicate that the lower 25^{th} percentile from an entire population roughly approximates the 75^{th} percentile for a reference population (USEPA, 2001). Table 9 summarizes the level of monitoring for nitrate + nitrite throughout Sub-ecoregion 58, and the resultant median value for ambient concentration. This value of 0.16 mg/L nitrate and nitrite is very supportive of the measured reference condition in surface water. The surface water values were not chosen because they 1) depict concentrations in surface waters under a mix of hydrologic conditions, and 2) represent a substantial geographic area beyond the New Jersey Highlands.

Table 9. USEPA Reference Condition Recommendations for Rivers and Streams in Sub-Ecoregion 58*.

	Sub-Ecoregion 58 (Ecoregion VIII)
# Stream Stations	803
# Records	19,854
Nitrate + Nitrite (mg/L)*	0.16

* 25th percentile based on all seasons data from 1990-1998, e.g., this value was calculated from the median of each of four seasons' 25th percentile. If a season was missing, the median was calculated with 3 seasons of data. If less than 3 seasons were used to derive the median, the entry was flagged **(z)**.

Therefore, for sites within the Highlands Preservation Area that are forested, the nitrate concentration target is established at 0.21 mg/L. For sites with mixed land use, the nitrate concentration target is established at 0.76 mg/L.

Nitrate-Dilution Model Results

The amount of recharge needed to dilute the effluent coming out of a septic tank is dependent on the volume of recharge available and the amount of nitrate discharged. In the Highlands Preservation Area the HWPPA mandates the maximum impervious cover to be 3%. By assuming a constant percentage of IC, the mathematical equation to calculate the nitrate concentration is straightforward and simple. The following are the relevant recharge and nitrate-loading parameters:

$A_{97\%}$ = size of the lot (with 3% IC) in acres
P = number of people per home
N = nitrate loading rate (pounds per person per year)
R = recharge rate (inches/year)
T = nitrate standard (mg/L)

Using the Trela-Douglas (1978) approach the lot size needed to generate enough clean recharge to dilute the nitrate in the effluent to the standard is:

$$A_{97\%} = 4.56 \frac{PN}{RT}$$

where the units are as defined above, and the 4.56 is a conversion factor for acres per lot. As detailed in the above narrative, the following nitrate-loading parameters were established:

P = 4 people per home
N = 10 pounds per person per year
T = 0.76 mg/L or 0.21 mg/L
R = 9.8 inches/year

The acreage necessary to adequately dilute nitrate nitrogen to no greater than 0.76 mg/L is 24.5 acres, which was rounded to 25 acres. The acreage necessary to adequately dilute nitrate nitrogen to no greater than 0.21 mg/L is 88.4 acres, which was rounded to 88 acres.

In addition, a means to equate this density to an allowable density of multi-residential (e.g., a duplex or triplex, etc.) and non-residential development that will use systems that discharge less than 2,000 gallons per day is also needed. Based upon census data, an assumption of 4 persons per household was used. As established in 7:9A-7.4, the Standards for Individual Subsurface Sewage Disposal Systems, the equivalent flow from a household of this size (4 persons, 3 bedrooms) is 500 gallons per day. Therefore, for all multi-residential and non-residential development proposing discharges to groundwater of less than 2,000 gallons per day, the standard is 25 acres per 500 gallons per day in mixed land use and 88 acres per 500 gallons in forested land use. The gallons generated by multi-residential and non-residential development will be as set forth in the Standards for Individual Subsurface Sewage Disposal Systems at N.J.A.C. 7:9A-7.4.

References

Anderson, D.L., R.J. Otis, J.I. McNeillie, and R.A. Apfel. 1994. In-situ Lysimeter Investigation of Pollutant Attenuation in the Vadose Zone of a Fine Sand. In *On-Site Wastewater Treatment: Proceedings of the Seventh International Symposium on Individual and Small Community Sewage Systems*. American Society of Agricultural Engineers, St. Joseph, MI.

Bachman, J.L. 1984. Nitrate in the Columbia Aquifer, Central Delmarva Peninsula, Maryland: USGS Water-Resources Investigators Report 84-4322. U.S. Geological Survey, Reston, VA.

Charles, E.G., C.Behroozi, J.Schooley, and J.L.Hoffman. 1993. A method for evaluating ground-water-recharge areas in New Jersey: New Jersey Geological Survey Report GSR-32. Trenton, NJ.

French, M.A. 2002. Ground-Water Recharge for New Jersey: N.J. Geologic Survey Digital Geodata Series DGS02-3, GIS shapefiles available on the Internet at www.njgeology.org

Hoffman, J.L. and Canace, R.J., 2004, A recharge-based nitrate-dilution model for New Jersey: N.J. Geological Survey Open-File Report 04-1, 27p.

Jones, R.A. and G.F. Lee. 1977. *Septic Tank Wastewater Disposal Systems as Phosphorus Sources for Surface Waters*. EPA 600/3-77-129. U.S. Environmental Protection Agency, Robert S. Kerr Environmental Research Laboratory, Ada, OK.

Linsley, R.K. and J.B. Franzini. 1979. Water Resources Engineering Third Edition. McGraw-Hill. Series in Water Resources and Environmental Engineering. P. 416-421.

Nicholson, R.S., S.D. McAuley, J.L. Barringer, and A.D. Gordon. 1996. Hydrogeology of, and ground-water flow in, valley-fill and carbonate-rock aquifer system near Long Valley in the New Jersey Highlands: U.S. Geological Survey Water-Resources Investigation Report 93-4157. West Trenton, N.J.

Omernik, J.M. 1999. Primary Distinguishing Characteristics of Level III Ecoregions of the Continental United States [Draft]. *Revised:* http://www.epa.gov/wed/pages/ecoregions

Posten, S.E. 1984. Estimation of mean groundwater runoff in hard-rock aquifers of New Jersey. Columbia University Seminar Series on Pollution and Water Resources, Vol. 16, 1984. Pergamon Press, New York, P. 109-154.

Robertson, W.D., E.A. Sudicky, J.A. Cherry, R.A. Rapaport, and R.J. Shimp. 1990. Impact of a Domestic Septic System on an Unconfined Sand Aquifer. In *Contaminant Transport in Groundwater*, ed. Kobus and Kinzelbach. Balkema, Rotterdam, Netherlands.

Serfes, M.E., 2004, Ground-water quality in the bedrock aquifers of the Highlands and Valley and Ridge physiographic provinces of New Jersey: N.J. Geological Survey report GSR-39, 27p.

Sikora, L.J. and R.B. Corey. 1976. Fate of nitrogen and phosphorus in soils under septic tank waste disposal fields. *Transactions of American Society of Agricultural Engineers* 19:866.

Tofflemire, T.J. and M. Chen. 1977. Phosphate removal by sands and soil. *Groundwater* 15:377-387.

Trela, J.J., and Douglas, L.A. 1978. Soils, septic systems and carrying capacity in New Jersey Pine Barens: paper presented at the First Annual Pine Barrens Research Conference, Atlantic City, NJ. May 22, 1978.

USDA. 2002. New York – New Jersey Highlands Regional Study: 2002 Update. United States Department of Agriculture/Forest Service. NA-TP-02-03.
Available on Internet at: http://www.crssa.rutgers.edu/projects/highlands/

USEPA. 2001. Ambient Water Quality Criteria Recommendations—Rivers and Streams in Nutrient Ecoregion VIII. Office of Water 4304. EPA 822-B-01-015.

USEPA. 2002. Onsite Wastewater Treatment Systems Manual. Office of Water. Office of Research and Development. EPA/625/R-00/008.

APPENDIX A.

Supplement: USGS Ground Water Data for Nitrate and Nitrite Concentration Analyses

As part of the U.S. Geological Survey's (USGS) program of disseminating water data to the public, the USGS maintains a distributed network of computers and fileservers for the storage and retrieval of water data collected through its activities at approximately 1.5 million sites around the country. This system is called the National Water Information System (NWIS). Many types of data are stored in this NWIS network, including: site information, time-series (flow, stage, precipitation, chemical), peak flow, ground water, and water quality parameters.

Data are retrieved by category of data, such as surface water, ground water, or water quality; and by geographic area. Further refinement is possible by selecting specific information and by defining the output desired. NWIS data comes from all 50 states, selected territories and border stations, from 1896 to present. Of the 1.5M sites with NWIS data, 80% are wells; 350,000 are water quality sites; and 19,000 are streamflow sites, of which over 5,000 are real-time. NWISWeb contains about 4.3 million Water Quality Samples; and 64 million Water Quality Sampling Results.

The goal of NWISWeb is to provide both internal and external users of USGS water information with an easy to use, geographically-seamless interface to the large volume of USGS water data maintained on 48 separate NWIS databases nationwide. Data is updated from the NWIS sites on a regularly scheduled basis, such that data outputs change with time. The ground water nitrate and nitrite concentrations for this analysis were exported on May 12, 2005, and can be affirmed by hard-copy printouts kept on file.

Table A-1. Set of latitude/longitude grids to represent Highlands area in order to assess nitrate levels.

Grid #	N-Latitude	S-Latitude	W-Longitude	E-Longitude
1	41º 17’ 00”	41º 09’ 00”	74º 33’ 00”	74º 15’ 00”
2	41º 09’ 01”	41º 00’ 00”	74º 40’ 00”	74º 10’ 00”
3	41º 00’ 01”	40º 50’ 00”	75º 00’ 00”	74º 20’ 00”
4	40º 50’ 01”	40º 37’ 00”	75º 00’ 00”	74º 29’ 00”
5	40º 50’ 01”	40º 32’ 00”	75º 10’ 00”	75º 00’ 01”

As explained in the Basis and Background document on page 17, a series of 5 grids that represent the Highlands Region was created based on longitude/latitude coordinates (Table A-1). All nitrate and nitrite records for each well within these grids were then compiled, resulting in 633 data points from 388 wells. To address the potential of a skewed distribution due to unrepresentative outliers, the 95th percentile was chosen as an appropriate data set. The 95th percentile was determined to be 3.6 mg/L nitrate and nitrite. In other words, 602 of the 633 data points were measured between 0.03 and 3.6 mg/L nitrate and nitrite (Figure A-1). The mean concentration for these 603 data points was then calculated as 0.8 mg/L of nitrate and nitrite. Table A-2. lists each USGS station identification number and correlating nitrogen sampling data.

Figure A-1.

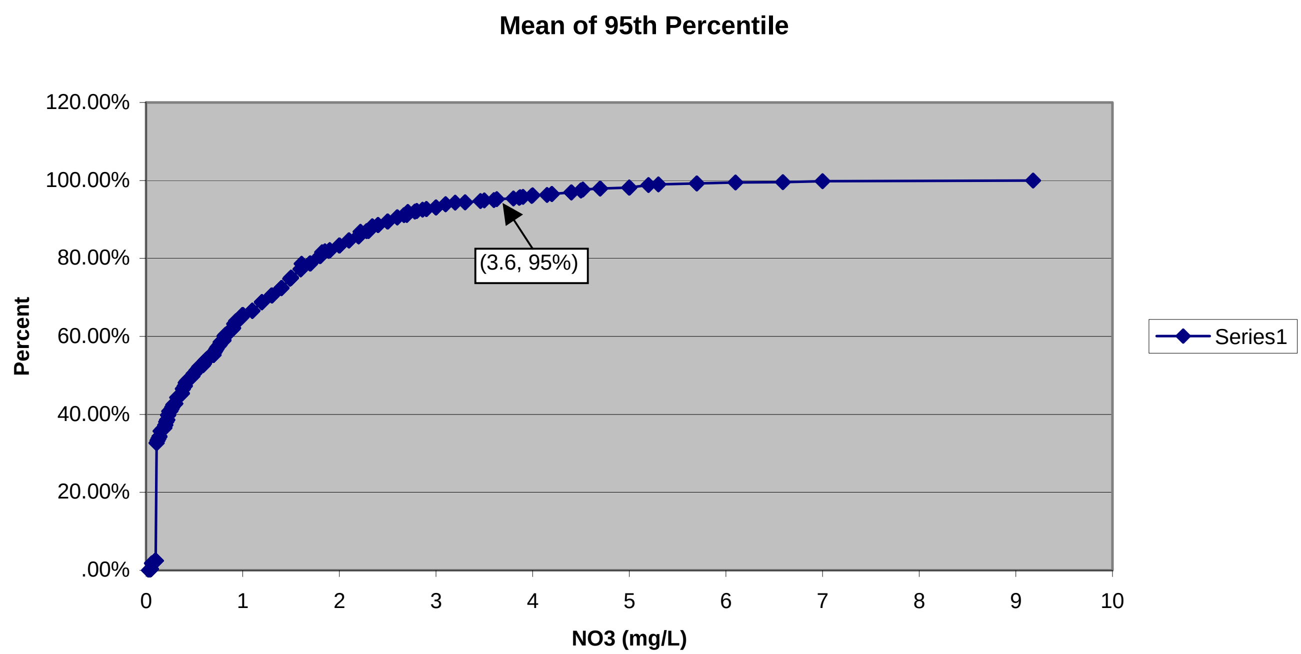


Table A-2.

Latitude/ Longitude "Grid"	USGS Station Identification Number	Sample Date	Sample Time	Nitrite & Nitrate (mg/L)
Section 1	410909074202001	8/25/1989	11:00	0.1
	411020074192701	9/12/1990	14:00	0.1
	411348074273901	9/24/2001	12:20	1.85
	411033074330001	9/19/1990	11:00	4.7
	411035074323601	9/17/1993	13:25	5
	411113074291301	10/2/1990	13:15	0.8
	411127074294001	9/12/1990	9:15	0.1
	411256074303001	9/16/1993	14:25	0.64
Section 2	410013074143301	4/10/1984	15:30	1.4
	410022074105201	3/7/1988	13:45	4.7
	410057074152501	5/24/1984	12:15	2.7
	410100074153601	5/24/1984	13:45	2.4
	410113074152801	5/8/1984	12:15	0.62
	410126074150801	5/21/1982	11:15	1.7
	410126074150801	4/25/1984	12:00	1.3
	410126074150801	9/12/1995	15:05	4.5
	410126074150801	3/7/1996	11:50	5
	410139074145301	5/7/1984	15:15	3.9
	410153074112701	6/14/1984	11:20	0.73
	410154074112301	6/14/1984	10:45	1.3
	410230074144301	6/7/1984	15:00	0.1

410301074132701	5/21/1982	12:15	2.9
410301074132701	9/15/1983	14:10	1.9
410301074132701	11/15/1983	11:10	2.9
410301074132701	12/2/1983	13:35	2.6
410301074133001	9/15/1983	12:25	2.3
410301074133001	11/15/1983	12:30	2.6
410301074133001	12/2/1983	12:10	2.4
410301074133001	6/16/1993	14:00	2.6
410303074133201	5/21/1982	13:10	0.92
410303074133201	9/15/1983	11:15	0.9
410303074133201	11/15/1983	14:50	0.91
410303074133201	12/2/1983	10:55	0.72
410313074112801	4/26/1984	11:30	0.22
410318074110101	4/18/1984	11:10	1.7
410318074110101	9/12/1995	10:25	2.2
410334074113701	5/10/1984	13:45	0.1
410337074102101	6/15/1984	10:55	1.7
410344074141601	5/25/1984	11:50	0.1
410359074105601	5/24/1984	11:00	0.12
410501074110101	5/21/1982	11:45	0.43
410501074110101	4/18/1984	12:10	0.33
410504074105601	9/12/1995	9:15	0.88
410508074133901	4/4/1984	14:15	0.1
410508074133901	9/28/1989	11:35	0.1
410539074102501	4/18/1984	13:20	0.16
410543074102301	5/21/1982	12:40	0.37
410543074102301	4/18/1984	14:15	0.1
410125074150401	5/21/1982	10:25	3.8
410125074150401	4/25/1984	11:00	3.6
410134074134901	5/21/1982	14:05	2.3
410134074134901	5/7/1984	11:50	2.5
410350074143001	5/25/1984	12:50	0.1
410514074134601	6/13/1984	11:40	0.1
410542074102401	5/21/1982	13:10	0.15
410542074102401	6/27/1984	10:50	0.24
410207074270001	6/22/1983	13:45	0.1
410207074270001	12/30/1985	15:00	0.1
410207074310401	11/27/1985	9:15	0.1
410209074170401	6/17/1993	12:40	0.89
410319074165601	9/14/1995	9:45	2
410408074170002	6/24/1993	14:30	0.4
410408074170002	9/14/1995	11:25	0.21
410527074155301	9/11/1990	14:00	0.9
410545074224801	8/25/1989	12:40	0.49
410615074240401	9/14/1995	15:50	0.09
410639074233201	9/26/1989	10:20	0.1
410720074144201	9/26/1989	14:00	1.1
410214074204501	11/20/2002	10:15	0.14
410207074385801	9/20/1995	14:30	2.5
410431074395801	9/25/1992	12:20	0.1

	410455074390801	8/26/1993	14:30	2.1
	410752074392601	9/27/1995	13:45	2
	410812074362101	9/21/1995	14:25	1.8
	410900074344001	10/4/1995	15:55	3
	410433074394001	11/18/2002	10:15	24.2
Section 3	405220074482201	9/25/2001	10:45	0.11
	405004074414801	8/11/1988	13:30	3.2
	405006074402001	11/28/1988	13:00	0.22
	405009074211701	8/20/1987	11:10	2.1
	405010074412401	8/30/1989	14:10	5.3
	405020074380701	5/15/1989	16:30	1.1
	405021074382601	8/8/1988	16:30	1.8
	405021074382602	8/8/1988	17:15	0.1
	405027074232301	9/18/1986	12:15	0.1
	405027074381201	9/13/1994	10:50	0.46
	405035074233701	8/31/1987	14:20	0.7
	405047074392901	5/7/1991	13:40	0.5
	405048074263501	9/25/1995	14:55	1.4
	405053074375501	8/9/1988	14:50	0.1
	405053074375502	8/9/1988	16:00	0.22
	405107074383501	11/3/1989	10:30	0.65
	405108074383601	8/10/1988	16:30	1.7
	405108074411001	9/6/1989	12:20	0.85
	405108074411001	9/27/1995	9:15	0.9
	405111074231001	12/16/1997	11:30	0.78
	405111074231001	9/21/1999	10:00	0.73
	405134074425801	8/10/1994	13:00	2.4
	405137074375001	10/31/1989	10:00	0.81
	405140074422801	4/12/1989	13:00	0.37
	405213074254101	8/31/1987	16:15	1.6
	405228074401301	8/19/1988	10:30	0.1
	405228074401401	8/19/1988	9:45	0.19
	405229074211101	11/25/1985	14:40	0.1
	405235074381801	8/22/1989	9:35	0.7
	405235074381801	8/22/1989	9:55	0.71
	405243074314801	11/26/1985	10:55	0.52
	405258074410401	9/27/1989	14:00	0.41
	405302074312002	1/14/1986	11:00	0.1
	405305074365901	8/25/1989	9:20	0.35
	405308074310601	1/14/1986	11:00	0.1
	405309074322901	11/26/1985	15:40	0.74
	405314074433601	9/13/1994	14:30	1
	405317074340402	11/26/1985	14:20	0.82
	405318074340702	12/17/1985	13:30	0.2
	405320074211201	5/5/1988	12:30	2.1
	405324074211601	8/13/1987	14:30	2.2
	405325074340503	8/24/1995	12:45	1.1
	405330074363801	10/25/1989	16:00	0.23
	405330074363802	10/26/1989	15:00	0.59

405330074363803	10/27/1989	12:00	1.4
405335074265001	1/7/1986	11:30	1.9
405335074265001	9/2/1987	12:45	0.34
405339074340801	11/26/1985	11:20	0.37
405344074273901	12/4/1985	16:30	0.25
405348074441501	4/5/1989	15:00	1.1
405355074380801	10/10/1995	9:40	3
405357074291501	11/26/1985	9:20	1.9
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405412074302801	11/25/1985	11:35	1.5
405412074352601	11/26/1985	9:10	0.75
405413074274101	11/26/1985	16:05	1.5
405413074274101	10/10/1995	12:55	3.5
405413074274101	3/11/1996	13:50	3.3
405414074310901	11/27/1985	10:25	1.9
405414074310901	10/29/1997	10:10	1.89
405414074310901	9/20/1999	10:00	1.49
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405444074363601	8/24/1989	9:10	6.1
405444074363601	10/16/2001	9:30	6.59
405451074264101	11/27/1985	11:30	0.83
405453074265501	8/10/1995	10:10	0.99
405456074265401	9/26/1995	13:05	0.3
405458074252801	11/26/1985	14:00	1.7
405458074252801	9/2/1987	10:45	1.5
405458074252801	10/10/1995	11:35	1.5
405500074202901	8/17/1987	9:00	0.41
405500074202901	8/17/1987	14:30	0.4
405503074362801	10/3/1995	8:35	0.05
405514074350301	8/3/1989	11:20	0.1
405517074295401	9/27/1995	11:40	1.6
405520074345801	8/3/1989	14:00	0.1
405521074344801	8/4/1989	10:40	0.76
405521074345001	8/2/1989	11:45	0.87
405521074345301	9/5/1989	16:55	0.1
405521074345801	8/3/1989	16:00	0.1
405521074345802	8/3/1989	14:35	0.1
405523074345201	8/2/1989	16:45	0.1
405523074345202	8/2/1989	15:15	0.1
405523074345203	8/28/1990	16:30	0.2
405523074345701	7/10/1990	8:35	0.1
405524074345001	8/2/1989	14:50	0.1
405524074345601	7/10/1990	10:00	0.1
405525074344801	5/31/1990	15:20	0.1
405525074345101	8/2/1989	13:00	0.1
405526074344701	8/1/1989	14:25	0.1
405526074345401	8/4/1989	12:20	0.1
405527074344801	8/1/1989	12:10	0.1
405527074345001	8/2/1989	9:50	0.1

405527074345401	8/4/1989	12:20	0.1
405528074345201	8/2/1989	10:00	0.1
405528074345202	8/1/1989	16:05	0.1
405528074345203	5/31/1990	12:20	0.1
405528074345301	8/4/1989	11:05	0.1
405530074344701	3/22/1990	15:15	0.1
405531074343401	8/7/1990	9:40	0.1
405531074343402	3/22/1990	14:05	0.1
405531074361901	6/14/1983	11:50	0.3
405542074261701	1/17/1986	14:00	0.1
405557074343001	8/12/1985	11:15	0.1
405557074343001	6/27/1989	16:50	0.1
405600074342301	7/24/1989	16:15	0.1
405600074342302	7/24/1989	17:25	0.13
405600074342303	3/22/1990	11:15	0.1
405600074343502	7/12/1989	15:00	0.1
405603074341801	10/20/1987	13:50	0.1
405603074341802	10/20/1987	12:10	0.1
405603074342401	7/24/1989	14:30	0.1
405603074342402	7/24/1989	12:45	0.1
405603074342403	7/18/1989	10:50	0.1
405603074343401	7/12/1989	14:45	0.1
405603074343402	7/6/1989	17:20	0.1
405603074343403	7/7/1989	13:25	0.1
405604074204001	8/13/1987	12:30	0.37
405604074204001	9/26/1995	14:35	0.35
405605074343301	7/25/1989	15:50	0.1
405605074343302	7/13/1989	15:40	0.1
405605074343303	7/13/1989	14:15	0.1
405606074343101	7/26/1989	11:10	0.1
405606074343102	7/26/1989	11:20	0.1
405606074343103	7/26/1989	14:20	0.1
405606074343401	8/13/1985	10:30	0.7
405606074343401	6/23/1989	13:05	2
405607074342801	7/13/1989	11:45	0.1
405607074342802	7/13/1989	14:40	0.1
405607074342803	7/13/1989	16:20	2.6
405607074342901	7/14/1989	11:40	0.22
405607074342902	7/14/1989	12:05	0.73
405607074342903	7/14/1989	10:30	0.1
405607074343201	8/13/1985	15:35	0.9
405607074343201	7/6/1989	12:20	0.26
405607074343201	1/25/1990	10:05	0.7
405607074343202	8/13/1985	11:50	0.1
405607074343202	6/30/1989	12:50	0.65
405607074343205	8/21/1985	18:00	0.3
405607074343205	7/5/1989	18:25	0.28
405608074201701	8/13/1987	9:45	0.16
405608074343101	8/13/1985	14:35	1.5
405608074343101	7/6/1989	14:15	1.8

405608074343102	10/21/1987	15:35	0.1
405608074343103	10/22/1987	10:10	0.1
405608074343201	7/25/1989	11:15	0.1
405608074343202	7/25/1989	14:30	1.2
405608074343501	8/12/1985	16:15	0.97
405608074343501	6/22/1989	17:45	1.1
405609074343201	8/12/1985	17:30	0.72
405609074343201	7/6/1989	17:10	1.4
405609074343201	1/25/1990	12:00	1.1
405609074343301	8/13/1985	17:30	1.8
405609074343301	7/6/1989	15:00	0.86
405609074343401	8/12/1985	15:50	1.1
405609074343401	7/7/1989	11:40	0.99
405610074343107	7/13/1989	11:05	2.3
405611074340701	10/21/1987	13:50	0.1
405611074340701	6/19/1989	11:40	0.1
405611074343001	7/12/1989	17:20	1.7
405611074343002	3/27/1990	11:15	1.4
405611074343003	3/27/1990	13:40	1.4
405611074343004	3/27/1990	15:00	0.8
405611074343601	8/12/1985	14:10	1.2
405611074343601	6/22/1989	11:50	1.3
405611074343601	1/24/1990	14:00	1.4
405612074340801	10/23/1987	11:40	0.1
405612074340801	6/19/1989	15:05	0.1
405612074340801	12/5/1989	9:35	0.1
405612074340802	10/23/1987	13:00	0.21
405612074340802	6/19/1989	13:45	0.1
405612074340802	12/5/1989	10:45	0.33
405613074343201	7/12/1989	17:45	1.6
405614074340401	10/20/1987	12:30	1.4
405614074340401	6/22/1989	10:15	0.76
405614074340401	11/29/1989	9:10	1.5
405614074340402	10/20/1987	14:00	1.2
405614074340402	6/22/1989	8:45	0.92
405614074340402	11/29/1989	10:15	1.3
405614074340701	11/15/1989	15:55	0.1
405614074340701	4/16/1990	13:35	0.1
405614074340702	11/15/1989	13:45	0.1
405614074340702	4/16/1990	11:25	0.1
405614074341101	11/8/1989	15:30	0.77
405614074341101	4/10/1990	12:10	1.1
405614074341102	11/8/1989	13:55	0.1
405614074341102	4/10/1990	10:50	0.1
405614074341103	11/8/1989	10:55	0.1
405614074341103	4/10/1990	9:30	0.1
405614074341201	8/14/1985	10:40	1.8
405614074341201	10/22/1987	12:50	0.62
405614074341201	6/15/1989	13:00	0.54
405614074341201	12/11/1989	15:55	0.1

405614074341201	12/14/1989	16:35	0.48
405614074341401	10/22/1987	11:30	0.14
405614074341401	6/16/1989	12:25	0.1
405615074340501	10/22/1987	17:30	0.99
405615074340501	6/24/1989	18:00	0.9
405615074340501	11/29/1989	13:20	0.92
405615074340501	3/13/1990	11:10	1
405615074340502	10/30/1987	10:30	0.1
405615074340502	6/24/1989	16:35	0.1
405615074340502	11/29/1989	14:35	0.1
405615074340502	3/21/1990	11:10	0.1
405615074340502	3/21/1990	11:11	0.1
405617074341201	10/28/1987	11:00	0.89
405617074341201	6/28/1989	11:30	0.84
405617074341201	12/7/1989	13:15	0.76
405617074341202	10/28/1987	9:45	1.9
405617074341202	6/28/1989	10:30	2.1
405617074341202	12/7/1989	10:30	1.4
405618074340101	11/17/1989	13:30	0.45
405618074340101	4/9/1990	18:10	0.5
405618074340102	4/9/1990	16:25	1.5
405619074335901	11/16/1989	15:10	1.9
405619074335901	4/9/1990	14:10	1.3
405619074335902	11/16/1989	12:15	0.23
405619074335902	4/9/1990	12:40	0.1
405619074340401	11/13/1989	16:40	0.56
405619074340401	4/11/1990	9:40	0.6
405619074340402	11/9/1989	15:25	0.1
405619074340402	4/17/1990	12:45	0.1
405619074340403	11/9/1989	13:30	2.5
405619074340403	4/17/1990	10:45	1.5
405619074340901	10/30/1987	15:00	0.1
405619074340901	6/23/1989	10:15	0.11
405619074340901	11/30/1989	15:30	0.1
405619074340901	3/23/1990	13:35	0.1
405619074340901	7/19/1994		0.74
405619074340902	10/30/1987	17:00	0.1
405619074340902	6/23/1989	11:45	0.1
405619074340902	12/7/1989	15:20	0.1
405619074340902	3/23/1990	15:25	0.1
405619074340902	7/19/1994		0.56
405619074340903	10/28/1987	13:00	2.3
405619074340903	6/23/1989	8:45	2.4
405619074340903	11/30/1989	14:10	1.6
405619074340903	3/13/1990	16:05	1.6
405619074340903	7/20/1994	12:00	1.6
405619074341501	12/14/1989	10:10	1.3
405619074341502	8/21/1985	17:30	0.1
405619074341502	10/26/1987	17:10	0.1
405619074341503	8/14/1985	13:20	0.1

405619074341503	10/27/1987	13:20	0.1
405619074341504	8/14/1985	12:10	1
405619074341504	10/27/1987	16:25	1.3
405619074341504	6/30/1989	10:50	1.2
405620074340401	8/16/1985	9:30	2.7
405620074340401	6/29/1989	16:55	3
405620074340401	12/12/1989	14:40	5
405620074340601	10/30/1987	12:10	0.1
405620074340601	6/20/1989	12:00	0.1
405620074340601	12/8/1989	8:40	0.1
405620074340602	10/30/1987	13:30	0.1
405620074340602	6/20/1989	10:40	0.1
405620074340602	12/8/1989	11:30	0.1
405620074340603	10/28/1987	14:20	4
405620074340603	6/19/1989	17:40	5.2
405620074340603	12/8/1989	10:10	4.4
405620074341301	11/14/1989	16:40	0.1
405620074341301	4/12/1990	14:10	0.1
405620074341302	11/14/1989	14:35	0.38
405620074341302	4/12/1990	15:35	0.8
405620074341302	4/12/1990	15:36	0.8
405620074341303	11/14/1989	11:45	1.2
405620074341303	4/12/1990	12:10	3
405620074431901	8/21/1985	11:30	0.1
405620074431901	10/28/1987	15:10	0.1
405620074431902	8/15/1985	17:30	0.1
405620074431902	10/22/1987	16:15	0.1
405620074431903	8/21/1985	13:45	0.1
405620074431903	10/28/1987	12:40	0.1
405620074431904	8/16/1985	11:40	1
405620074431904	10/27/1987	10:15	1.4
405622074340201	10/21/1987	15:30	1.4
405622074340201	6/26/1989	9:50	2
405622074340201	12/6/1989	9:30	2.1
405622074340202	10/21/1987	16:45	2.7
405622074340202	6/26/1989	8:40	3.1
405622074340202	12/6/1989	10:30	3
405622074341101	11/2/1987	15:30	0.48
405622074341101	6/21/1989	16:40	0.1
405622074341101	12/1/1989	14:10	0.19
405622074341101	3/23/1990	17:25	0.1
405622074341101	7/21/1994	13:00	0.1
405622074341102	11/2/1987	12:50	0.14
405622074341102	6/21/1989	15:00	0.12
405622074341102	12/1/1989	9:55	0.1
405622074341102	3/14/1990	13:25	0.1
405622074341102	9/20/1994	13:00	0.27
405622074341103	11/2/1987	14:20	0.14
405622074341103	6/21/1989	12:55	0.29
405622074341103	12/1/1989	11:30	0.23

405622074341103	3/14/1990	14:55	0.22
405622074341103	7/21/1994	13:10	0.67
405623074341101	8/14/1985	15:10	0.44
405623074341101	6/22/1989	13:53	0.23
405623074341101	4/12/1990	17:25	0.4
405623074341301	8/14/1985	18:00	0.1
405623074341301	10/23/1987	10:15	0.1
405623074341301	1/30/1990	11:40	0.1
405623074341302	8/14/1985	19:00	0.38
405623074341302	10/29/1987	15:50	0.1
405623074341302	6/23/1989	15:25	0.14
405623074341302	11/20/1989	15:55	0.1
405623074341302	3/15/1990	11:00	0.3
405623074341303	8/16/1985	11:30	0.1
405623074341303	10/30/1987	11:15	0.1
405623074341303	1/31/1990	13:25	0.1
405623074341304	8/16/1985	10:15	0.1
405623074341304	10/29/1987	14:50	0.1
405623074341304	1/30/1990	14:55	0.1
405623074341305	10/29/1987	17:00	0.1
405623074341305	6/23/1989	17:00	0.1
405623074341305	12/1/1989	16:10	0.1
405623074341305	3/15/1990	15:00	0.1
405623074341306	11/20/1989	17:30	0.1
405623074341306	4/13/1990	14:10	0.1
405623074341701	11/28/1989	8:45	0.53
405623074341701	4/13/1990	10:50	0.6
405623074341702	11/28/1989	10:25	0.55
405623074341702	4/13/1990	9:25	0.6
405623074341703	11/28/1989	13:00	0.1
405623074341703	4/13/1990	12:25	0.1
405624074341001	8/15/1985	15:15	0.1
405624074341003	8/13/1985	16:15	0.93
405624074341003	11/16/1987		0.77
405624074341003	6/26/1989	13:50	0.32
405624074341003	12/15/1989	9:20	0.46
405624074341003	4/10/1990	18:35	0.1
405624074341201	8/14/1985	16:40	0.95
405624074341201	6/29/1989	14:50	0.5
405624074341201	12/8/1989	15:50	0.54
405625074340901	10/26/1987	14:50	0.1
405625074340901	6/21/1989	9:00	0.1
405625074340901	12/13/1989	15:45	0.1
405625074340902	10/26/1987	14:00	1.7
405625074340902	6/21/1989	10:35	1.4
405625074340902	12/13/1989	14:10	1.5
405625074342001	8/15/1985	9:15	0.1
405625074342001	10/22/1987	14:30	0.1
405625074342001	6/28/1989	17:10	0.1
405625074342001	12/14/1989	13:30	0.46

405626074341101	8/14/1985	12:40	0.1
405626074341101	10/27/1987	10:40	0.38
405626074341101	6/27/1989	15:25	0.1
405626074341101	12/18/1989	16:50	0.19
405626074341601	8/15/1985	10:45	1.5
405626074341601	10/27/1987	14:30	1.2
405626074341601	6/22/1989	17:20	0.28
405626074341601	12/6/1989	12:20	0.59
405626074341801	10/29/1987	11:30	0.14
405626074341801	6/24/1989	12:40	0.14
405626074341801	6/24/1989	12:41	0.12
405626074341801	12/5/1989	14:15	0.27
405626074341801	12/5/1989	14:16	0.26
405626074341801	3/14/1990	10:35	0.1
405626074341801	3/14/1990	10:36	0.1
405626074341801	6/6/1990	8:40	0.2
405626074341802	10/29/1987	13:00	1
405626074341802	6/24/1989	11:15	2.2
405626074341802	12/5/1989	12:45	0.75
405626074341802	3/20/1990	12:15	0.8
405626074341802	6/6/1990	10:00	0.7
405627074340701	5/16/1990	15:00	0.1
405627074340702	8/16/1985	13:00	1.3
405627074340702	11/16/1987		0.97
405627074340702	6/27/1989	13:45	0.71
405627074340702	12/15/1989	14:05	0.94
405627074341101	10/26/1987	16:20	0.61
405627074341101	6/29/1989	11:00	0.26
405627074341101	12/18/1989	14:55	0.4
405627074341601	8/15/1985	12:30	0.85
405627074341601	10/27/1987	12:20	0.37
405627074341601	6/28/1989	14:00	0.17
405627074341601	12/5/1989	16:05	0.3
405627074341701	8/15/1985	13:00	3.1
405627074341701	10/29/1987	15:00	0.22
405627074341701	6/22/1989	15:50	4.2
405627074341701	11/21/1989	15:30	2.8
405627074341701	3/20/1990	16:05	1.5
405627074341702	11/21/1989	12:35	1.4
405627074341702	4/11/1990	11:15	1.4
405627074341703	11/28/1989	16:20	0.1
405627074341703	4/11/1990	12:45	0.1
405627074341703	4/11/1990	12:46	0.1
405628074341801	8/15/1985	11:00	1.2
405628074341801	10/23/1987	15:00	0.1
405628074341801	6/20/1989	14:50	0.63
405628074341801	12/6/1989	14:05	0.1
405628074341801	3/6/1990	15:30	0.6
405629074340901	10/23/1987	10:00	0.1
405629074340901	6/29/1989	12:50	0.1

405629074340901	12/15/1989	11:45	0.1
405629074341101	10/22/1987	16:00	1.6
405629074341101	6/28/1989	15:50	0.87
405629074341501	8/16/1985	13:15	2.4
405629074341501	10/28/1987	16:00	0.23
405629074341501	6/20/1989	16:55	1.1
405629074341501	12/8/1989	14:15	0.3
405630074340001	1/5/1984		0.1
405630074341201	8/15/1985	14:30	0.1
405630074341202	10/26/1987	12:00	0.1
405630074341202	6/27/1989	11:00	0.1
405630074341202	12/12/1989	11:45	0.1
405630074341203	6/27/1989	9:40	0.1
405630074341203	12/12/1989	9:50	0.1
405630074341602	8/14/1985	10:00	1.2
405630074341602	6/16/1989	15:50	0.53
405630074341602	12/13/1989	11:15	1.3
405630074341604	10/19/1987	15:30	0.19
405630074341605	10/19/1987	14:45	0.1
405630074341605	6/16/1989	14:50	0.95
405630074341605	12/13/1989	10:00	0.25
405631074342001	11/27/1989	16:20	0.25
405631074342001	4/10/1990	14:10	0.2
405631074342002	11/28/1989	14:50	2.2
405631074342002	4/10/1990	15:20	1.9
405632074335601	12/28/1983	11:00	0.1
405632074335901	11/3/1987	13:00	0.1
405632074341201	8/15/1985	16:00	0.1
405632074341401	8/14/1985	11:00	0.1
405632074341401	10/22/1987	9:40	0.1
405632074341401	6/26/1989	11:50	0.1
405632074341401	11/30/1989	10:20	0.1
405632074341401	4/10/1990	18:36	1.9
405632074341402	7/20/1989	14:00	0.1
405632074341402	11/30/1989	11:45	0.1
405632074341402	4/10/1990	17:05	0.1
405635074333901	2/19/1986	12:30	0.76
405635074333901	11/17/1987	12:45	0.48
405635074333901	11/19/1987	10:30	0.48
405637074332601	5/16/1990	17:00	0.3
405644074332601	12/8/1987	12:45	0.37
405644074332601	12/10/1987	11:50	0.37
405644074332601	5/16/1990	12:20	0.2
405909074351101	8/28/1989	10:40	0.1
405430074401001	10/6/1994	11:30	0.19
405220074455301	8/28/2000	10:01	4.15
405220074455301	2/20/2003	14:50	4.52
405309074315301	11/13/2002	10:00	0.14
405351074433201	10/4/2000	10:43	0.08
405537074361401	9/11/2003	12:50	0.04

	405018074274501	10/15/1997	14:35	2.22
	405018074274501	9/16/1999	9:00	2.34
	405631074475001	9/17/2001	13:00	10.5
	405414074424601	6/22/1993	12:00	2.5
	405414074424601	10/11/1995	9:50	2.5
	405715074441801	11/5/1998	12:00	3.99
	405715074441801	8/16/1999	10:00	3.46
	405840074440601	9/21/1995	11:00	0.38
	405840074440601	11/23/1998	12:00	0.42
	405925074442501	8/29/1995	11:40	1.1
	405932074441701	9/15/1994	11:10	1.1
	405950074441501	9/21/1995	12:05	1.5
	405708074450501	7/23/1998	10:00	2.78
	405909074450601	11/23/1998	15:00	0.35
	405459074451201	7/17/2001	13:00	0.14
	405154074585701	9/24/2001	10:00	0.03
	405035074502201	9/27/2001	12:10	0.9
	405003074495001	9/7/1995	12:40	0.05
	405007074565901	9/22/1992	14:00	2.2
	405017074564801	9/22/1992	11:40	2.5
	405112074485201	8/26/1992	13:40	0.38
	405113074485301	9/9/1992	11:40	0.52
	405200074571801	9/29/1992	12:00	0.71
	405207074494001	9/11/1990	12:30	0.1
	405227074482701	9/14/1992	10:40	0.17
	405227074482701	10/11/1995	15:10	0.13
	405230074492501	9/28/1990	11:30	0.8
	405453074515001	9/23/1992	15:20	0.05
	405453074515001	9/16/1994	14:30	0.05
	405458074545601	8/25/1993	13:30	0.05
	405459074513401	9/23/1992	12:10	0.05
	405527074484201	8/28/1995	11:50	0.05
	405835074563801	4/11/1991	13:10	0.05
	405919074520601	8/2/1988	13:00	0.21
	405919074520601	9/9/1991	14:15	1.7
	405359074522501	9/21/1992	13:45	1.1
Section 4	403733074561901	6/21/1988	11:15	4.5
	403750074581101	3/3/1988	12:00	1
	403800074563701	9/12/1995	10:45	0.11
	403804074541801	9/6/1994	12:10	2.2
	403923074543301	9/11/1991	13:25	1.3
	404019074444601	5/27/1987	12:30	2.7
	404019074444602	8/16/1994	13:00	2
	404113074555301	9/6/1990	11:45	0.3
	404153074531301	9/25/1990	13:20	0.9
	404204074531901	9/19/1989	10:30	1.2
	404233074544701	9/14/1990	13:00	3.3
	404244074515001	11/22/1988	11:45	2.3
	404244074515001	10/30/1989	16:00	2

404416074464501	11/23/1988	11:45	0.22
404416074464501	10/30/1989	13:00	0.27
404431074495801	11/2/1989	13:30	4.4
403921074515901	6/24/2003	10:00	9.18
404038074294601	9/1/1987	13:30	1.6
404212074294701	8/14/1987	15:00	0.1
404621074352201	6/6/1989	13:00	0.23
404633074374001	9/5/1990	12:45	0.4
404712074454701	9/20/1994	12:45	2.9
404720074361001	12/1/1988	12:00	2.3
404720074361001	8/18/1999	11:21	2.1
404720074361001	12/12/2002	11:20	2.67
404721074355401	8/31/1999	11:23	1.61
404725074452101	8/25/1988	10:30	1.3
404727074330001	9/26/1990	15:40	1.1
404727074371301	9/27/1990	10:35	1.6
404740074315301	9/19/1990	15:50	1.8
404740074322001	9/24/1990	12:50	0.8
404753074314001	9/27/1990	17:15	0.6
404809074415501	5/2/1990	16:20	1
404809074415502	5/2/1990	14:00	2.3
404831074433801	8/24/1988	14:00	0.41
404835074465801	11/30/1988	12:45	1.3
404902074423201	8/12/1988	10:00	1.4
404915074474201	11/16/1988	12:30	1.5
404921074334901	1/7/1986	15:00	1.1
404934074385901	2/27/1990	17:50	0.3
404934074400501	9/28/1990	14:30	0.5
404936074491901	8/11/1995	10:23	2.1
404936074491901	10/29/1997	14:05	2.34
404941074300601	9/12/1990	12:30	4.2
404954074412202	9/30/1992	11:40	0.22
404958074423701	8/12/1988	12:25	0.98
404630074322701	9/9/2003	14:00	0.81
404603074315801	8/28/2003	13:00	0.11
404555074324101	8/26/2003	13:45	1.82
404724074412301	8/28/2000	11:52	2.86
404724074412301	12/17/2002	11:50	3.87
404936074423101	10/22/2002	10:15	0.65
404545074301801	9/1/1987	10:30	1.2
404545074301801	8/16/1988	12:45	1.2
404828074403501	7/8/2003	10:30	0.05
404900074462501	11/17/1988	12:30	0.1
403923074343501	8/19/1994	13:00	1.7
404142074311601	12/3/1987	13:05	0.1
404339074324201	10/1/1997	13:35	0.09
404339074324201	9/11/2000	10:21	0.13
404339074324201	11/20/2002	12:20	0.06
403925074343501	8/28/1987	14:40	2.2
404527074583701	8/24/1999	10:35	3.63

	404548074554201	9/17/1993	15:00	2.8
	404653074550201	8/12/1993	15:45	2
	404838074530801	9/16/1993	16:00	0.05
	404911074584901	8/30/1999	10:59	2.28
	404911074584901	9/10/2001	10:14	2.4
	404911074584901	12/18/2002	12:30	2.71
	404937074580501	6/25/2003	11:30	4.2
Section 5	403424075054801	4/30/1987	12:00	2
	403424075054801	6/29/1988	10:45	1.7
	403940074594001	8/27/1990	11:30	5.7
	403719075091801	9/24/2001	11:10	3.86
	403953075095401	9/6/1994	10:10	5
	404008075092701	7/19/1988	10:20	4.4
	404008075092701	9/25/1991	13:05	1.5
	404349075031301	9/27/1994	12:30	7
	404737075004401	8/27/1992	13:50	0.43