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Environmental Impact Statement

Appendix 10

Construction Phase Stormwater Quality Management Plan

The Belleayre Resort at Catskill Park

APPENDIX 10

CONSTRUCTION STORMWATER QUALITY MODELING

The following section describes quantitatively how water quality in local surface water resources, as well as the Ashokan and Pepacton Reservoirs, will be protected as a result of implementing the measures described in Appendix 9, "Construction Phase Stormwater Quantity Management Plan" of this DEIS.

In the absence of stormwater quality controls the ecology of the Pepacton and Ashokan watersheds as well as the surface water quality may potentially be impaired. Unabated stormwater may contain suspended solids concentrations as high as 3000 mg/l (±1,950 NTU) and export up to 404 kg/yr of phosphorus, annually. With the implementation of the control measures proposed herein, it is anticipated that turbidity may be reduced to 25 – 50 NTU and the annual phosphorus yield will be reduced to ±15 to 61 kg/yr.

1. Introduction

In order to develop the stormwater management system described above, it was necessary to predict the quality of the stormwater runoff from the construction site. This assessment of quality then allowed for the development of the treatment system and use of flocculants for reducing stormwater turbidity. In particular, the last part of this analysis examines the watershed implications of the stormwater runoff based on the detailed phasing and work sequence described in the Stormwater Pollution Prevention Plan (Appendix 11).

2. Total Suspended Solids

A. Method

Estimating the amount of total phosphorus and total suspended solids expected to be contained in the stormwater runoff from the area of disturbance was determined based on the concept plan. A mass balance approach was taken to determine construction stormwater total suspended solids (TSS) that are expected in the temporary detention basins for Phase 2 construction on Big Indian Country Club, described more fully in Appendix 9, "Construction Phase Stormwater Quantity Management Plan". A pollutant runoff concentration approach was utilized to estimate phosphorus export during construction of Big Indian Country Club and Wildacres Resort (see Section 3 of this Appendix). An estimated mass of TSS is simulated to enter a detention basin where the particles would settle, resuspend, and undergo chemical reactions prior to discharge. Export coefficients or runoff concentrations were gathered from various literature sources. The use of export coefficients is widely used as a straightforward methodology to estimate pollutant export from various land uses. The NYSDEP utilized land use-export coefficients to determine the Total Maximum Daily Loads (TMDLs) of different pollutants for the reservoirs.

Numerous stormwater modeling programs exist that assess the quantity of stormwater from construction activities since these models are based upon a weighted curve number that can be established for bare soil conditions. No models have been developed to specifically assess stormwater quality during the construction phase of site development. Water quality models have been developed to address operations as opposed to construction.

In attempting to adapt operational phase stormwater quality models to evaluate construction impacts, numerous challenges arose. WinSLAMM version 8.4 (Pitt and Vorhees, 1996) was utilized to analyze stormwater impacts that may occur during operation of this project. WinSLAMM is an empirical modeling approach that uses predefined land covers and management practices to assess stormwater quality. User defined inputs include relative areas of differing land uses, rainfall data, outfall controls and drainage controls. Standard pollutant distribution, solids concentration and street delivery files are incorporated into the modeling package. These standardized parameter files characterize the transport of pollutants over different road surfaces to account for drainage, roughness, curbs, and other physical characteristics that affect the transport of pollutants. These files have been calibrated and verified to various settings in the northern temperate climate, including Toronto, Canada and Madison, WI. WinSLAMM was not representative of pollutant loads that may be expected from construction activities since the incorporated land use files did not accurately characterize construction sites. Vacant land was initially chosen to represent disturbed areas. This land use did not accurately represent the unstabilized characteristics of construction sites. The developers of the WinSLAMM model confirmed that the model was not appropriate for construction sites (Dr. Robert Pitt personal communication to The LA Group, October 2002).

In order to estimate the amounts of sediment and phosphorus export, each parameter's expected loading rate or runoff concentration is assessed based on literature values of measured export land use coefficients to determine the total loading rate. Therefore, a mass balance approach has been employed to assess the potential for construction site runoff that may accumulate in the temporary construction detention basins. The quantitative simulation represents the quality of the accumulated stormwater in the detention basins prior to flocculent enhanced treatment. The estimated stormwater quality in the basin becomes the basis for determining the effluent quality. Treated runoff quality is determined by using a percent removal for the individual contaminants. The percent removals were determined based on literature values and/or laboratory testing with the Chitosan® flocculent.

Stella 6.0 (Hps Inc., 1998) is a software program designed for system analysis applications. Transport mechanisms can be mathematically represented in a systems setting to assess pollutant fate and transport. Solids in stormwater adsorb, settle, re-suspend, disperse, and are transported at varying rates according to changes in chemical composition of the solution. Defining these transport mechanisms over control volume yields pollutant concentrations in the volume of water. Although it is anticipated that the accumulated stormwater will be treated and pumped out of the detention basin, the formulas estimate the TSS of the water that exists in the basin prior to treatment and discharge. The treatment train is assessed as a simple percent removal of the total loading or mass within the detention basins. Runoff concentrations used in the simulation have been estimated from nutrient export literature values for different land uses.

B. Model Inputs

A concentration-runoff approach was taken to estimate the water quality of runoff from the construction sites. This approach is very similar to the nutrient export approach that calculates mass nutrient exports from a given parcel of land. The primary difference is that the concentration-runoff approach is based on a pollutant concentrations that would be expected from individual rain events or annual averages based on the volume of water that is derived from each land use. Nutrient export coefficients and runoff pollutant concentrations were gathered through a literature survey and then used to determine the respective pollutant concentrations by estimating the volume of runoff for a given parcel of land for a particular land use. The precipitation values that have been used are conservative in nature to represent dry conditions and, thus, the most concentrated runoff.

The nutrient export coefficient approach (Reckhow et al, 1989; Novotny and Olem, 1994) calculates mass nutrient export from a given parcel of land as the product of land area and a unit load. The unit load, or nutrient export coefficient, is a measure of the nutrient export (mass load) per unit area per unit time, for example, kg of TP per acre per year. Unit loads will vary by the type of land cover and the nature of land use practices in a particular area. Numerous field studies have been conducted to estimate the amount of nitrogen and phosphorus entering surface waters from various land uses.

The runoff pollutant concentrations used for the various land cover categories (Table 1) are based upon gathered nutrient export coefficients divided by respective runoff volumes or observed runoff concentrations presented in literature. A summary of literature values that have been used and the respective sources are presented in Table 1.

Table 1
Summary of TSS Values Presented in Literature

A. Total Suspended Solids

Land Use	Total Suspended Solids	Source
Construction Site	683.95 (mg/l)	Kayhanian, 2000
	4.7 (T/ha/yr)	Starrett, 2000
	49,000 (T/km^2/yr)	Borman and Likens, 1979
	85 mg/l	MDID, 2002
Forest	3.3 (T/km^2/yr)	Borman and Likens, 1979
	85 mg/l	MDID, 2000
Grassland/Landscaped	101 mg/l	MDID, 2000
Urban/Impervious	150mg/l	Stormcenter.net*
	200 mg/l	MDID, 2000

*National averages derived from NURP

B. Total Phosphorus

Land Use	Total Phosphorus	Source
Construction Site	0.066 mg/l	NCENR, 1997
(Bare soil/Agriculture)	0.95 mg/l	Kayhanian et. al., 2000
Forest	0.008 mg/l	NCENR, 1997
Grassland/Landscaped	0.04 mg/l	NCENR, 1997
Urban/Impervious	0.5 mg/l	Stormcenter.net
	0.098 mg/l	NCENR, 1997

Forested areas include both natural and managed forests. Literature reports do not accurately differentiate between managed and unmanaged forests, so all forest categories were assigned the median forest values. Nutrient export from urban areas includes runoff from residential and commercial areas that typically contain a large percentage of impervious coverage. Disturbed land was classified as agricultural because these areas were found to consist primarily of recently plowed fields (Khorram et al, 1992). Since literature values for low density vegetation and disturbed land were not available, values for these categories used in the RTI study were intermediate between the values for forested and agricultural land, and were selected taking into account the types of land represented by these two classes.

Where nutrient export loads were used to calculate runoff concentrations from North Carolina data, an annual rainfall of 48 inches was used. This rainfall is significantly lower than the observed rainfall in the area that may be as high as 56". The low rainfall estimate was used to provide a measure of safety by representing the most concentrated, worst case, scenario.

C. Discussion

The export coefficient approach has a number of limitations. Some of these are inherent in the method itself, while others result from the specific data used.

a. The model approach assumes that a volume of water exists in the basin at all times.
b. The export coefficients are not based upon site-specific studies of the local drainage basins, but rely on literature estimates. These estimates are based on studies conducted in similar and different vegetative and climatic areas, but soils and other features of the study sites may differ from those in local watersheds.
c. Export estimates for urban areas do not explicitly account for inputs from impervious areas, but rather rooftops, impervious, limited grass, etc.

The modeling approach is conservative in nature since a number of the input parameters and the model setup represent worst-case conditions.

- The calculation of runoff concentrations were determined under dry conditions to represent the most concentrated runoff that may be expected from different land uses.
- Total Phosphorus removal was estimated to be 85%, which is based on the expected removal of the suspended particulate solids and the phosphorus phase (particulate vs. soluble). As the majority of the phosphorus is anticipated to be in the particulate phase, sorbed to solids, removal will be significant during flocculant enhanced settling. Filterable phosphorus will undergo limited removal as it is anticipated that infiltration will be varied throughout the project site due to the existence of a hardpan layer in the subsurface. This estimate is conservative in nature since TP removal may typically reach 99% with the use of flocculants.
-
- Source control practices to be used in this project, such as minimizing the area of disturbance, the utilization of tackifiers to prevent soil particles from becoming dislodged, temporary stabilization, and silt fences to restrict the transport of suspended solids can vastly reduce the runoff pollutant concentrations that would be expected in the temporary construction detention basins. Source control measures were not incorporated into the model.

The use of land-use-specific nutrient export (mass) or runoff concentration to estimate nutrient yields are the best method available given that detailed export models have not been developed that accurately assess construction site impacts. This approach is similar to the methodology used by the NYSDEP to establish the TMDLs for the Ashokan and Pepacton reservoirs. Despite the limitations of this approach, the results provide a rough approximation of the loading to the reservoir watersheds.

D. Model Results

The relative sediment load from each subcatchment has been determined using the literature concentrations and resultant flow from a 10-year 24-hour storm of 6 inches on bare soils. The pollutants are anticipated to travel at different rates via overland flow and collect in the detention basins. Decreased water velocities in the retention basins will cause the particles to settle to the bottom of the basin. Other particles that remain in suspension in the basins will settle out after the basins are treated with the flocculent.

Once the model was constructed, initial literature values were inputted and verified. An area of 1 acre was used for a model simulation. The predicted runoff concentration was then compared to the literature values. The formulas were confirmed to match the literature values by adjusting the initial volume of the basins and a very low settling velocity that would be consistent with the high percentage of small particles measured during sieve and hydrometer testing of the site' soils (See Appendix 12). Variables, such as settling, vary with particle size distribution and were conservatively estimated on the low end to account for the limited removal of small particles. It is necessary to have the model establish an accurate prediction of the water quality by assuring that the model is producing results that can be verified by other methods. The formulas have been verified by use of other predictive models such as the USLE and results of the analysis have been compared to literature values for the individual land uses. The predicted TSS runoff concentration for 1 acre of each land use matched literature values very well as shown in Table 2.

Table 2
TSS Model Verification

Land Use	Literature Value (mg/l)	Model Predicted Values (mg/l)
Forest	37.0	37.7
Landscaped	37.0	37.7
Impervious/Road	150.0	152.0
Construction	684.0	696.5

The model results were then verified against the Universal Soil Loss Equation (USLE). The sediment yield was calculated using USLE, with the following variables; 300' slope length, 8% slope, rainfall factor of 140, and a soil erodability factor of 0.6. Three subcatchments were modeled to determine the annual soil loss from each subcatchment and compared to the calculated values. There is no statistically significant difference in the model values or those calculated using USLE (Figure 1 and Table 3).

Figure 1
Predicted Annual Sediment Yield and USLE Calculated Sediment Yield

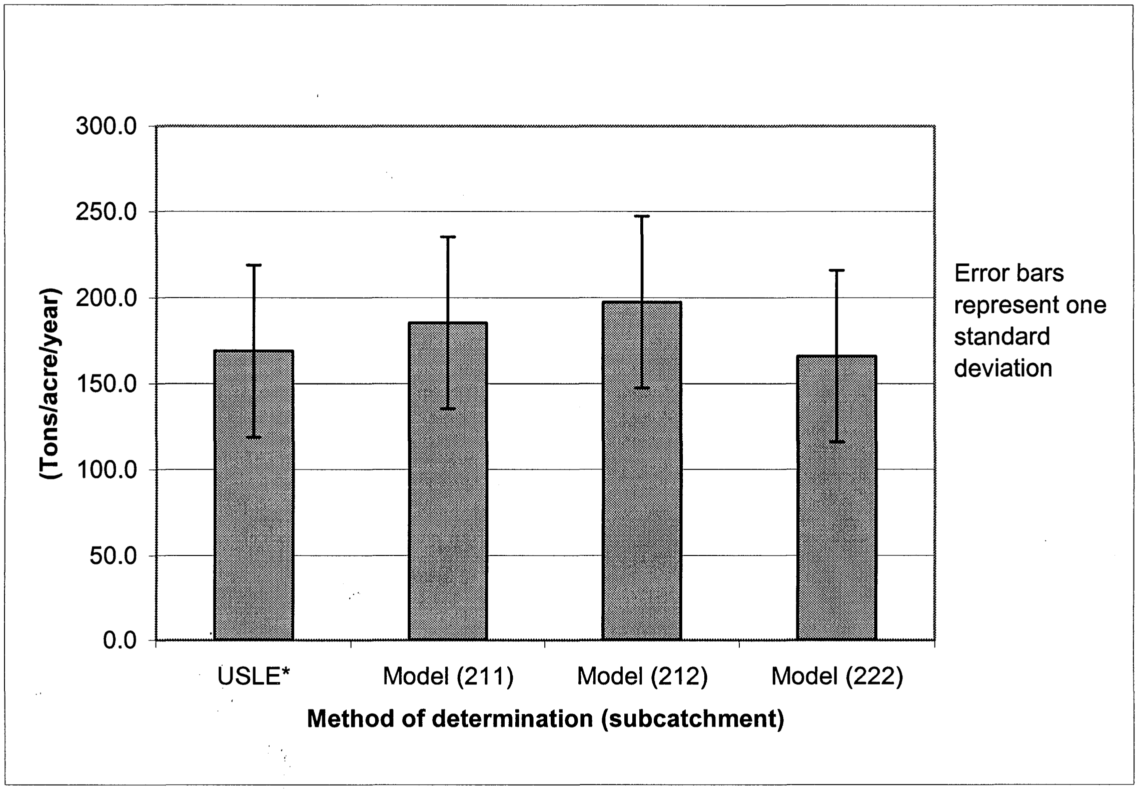


Table 3
Sediment Yield Model Comparison

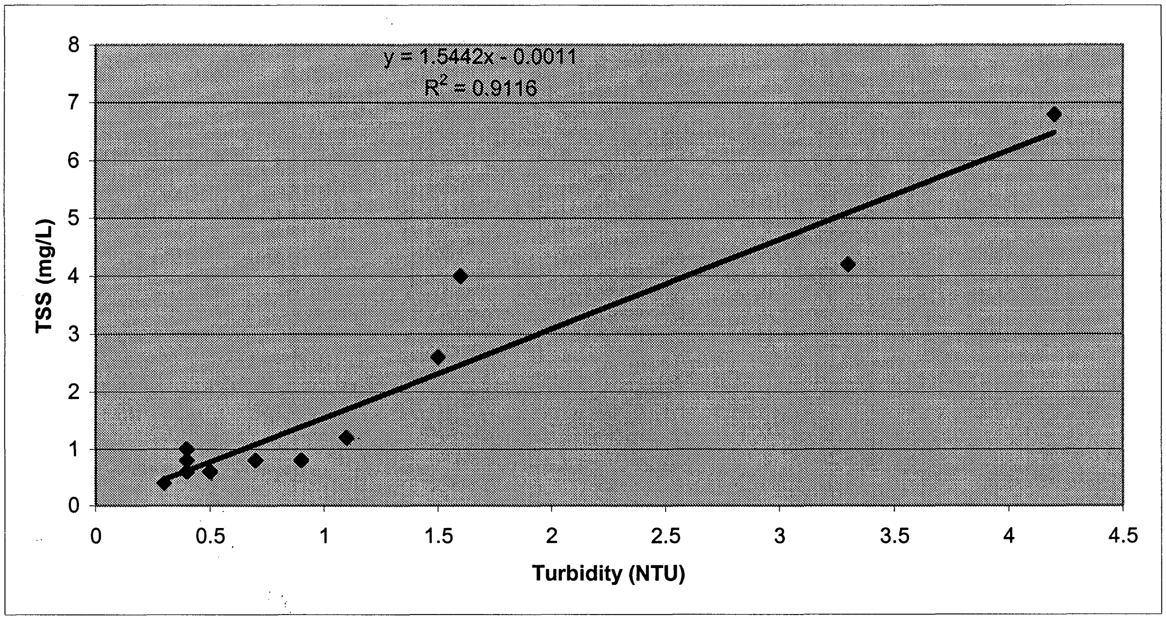
Method	Value (Tons/acre/yr)
USLE*	169.0
Model (211)	185.4
Model (212)	197.5
Model (222)	166.0

*Calculated with a 300' slope length at 8% slope, k=0.06, R=140

In all cases, the predicted values were within 1 standard deviation of the dataset. This confirmed that the model is representative of runoff and transport mechanisms that may occur on construction sites.

The TSS concentrations were determined in each basin to assess the clarity impacts and subsequent flocculant dosage. The relationship between TSS concentration and turbidity was determined using data from NYCDEP stream sampling from Birch Creek at site Belle2. The Belle2 dataset was considered to be the closest sampling point to the site and most characteristic of the soil hue and color that exists on the site. A linear relationship between TSS and Turbidity was observed, R^2=0.91 (Figure 2) in the DEP data from Birch Creek. Therefore, it is possible to predict turbidity using the TSS data generated by the process described above. Construction stormwater in the temporary detention basins was determined using this linear relationship.

Figure 2
Turbidity and TSS Relation Ship, as Observed by NYDEP



The turbidity of the stormwater that accumulates in the temporary detention basins is generally expected to be between 900 and 4000 NTU (Figure 3). The TSS concentration is also expected to generally be between 1500 and 6000 mg/l. The difference in these two values is that the TSS is a concentration and turbidity is a measure of the clarity in NTUs.

The clarity of a water body is determined by TSS concentration as well as soil characteristics such as color and hue. The values presented below are typical values that may be expected from construction sites and disturbed soils.

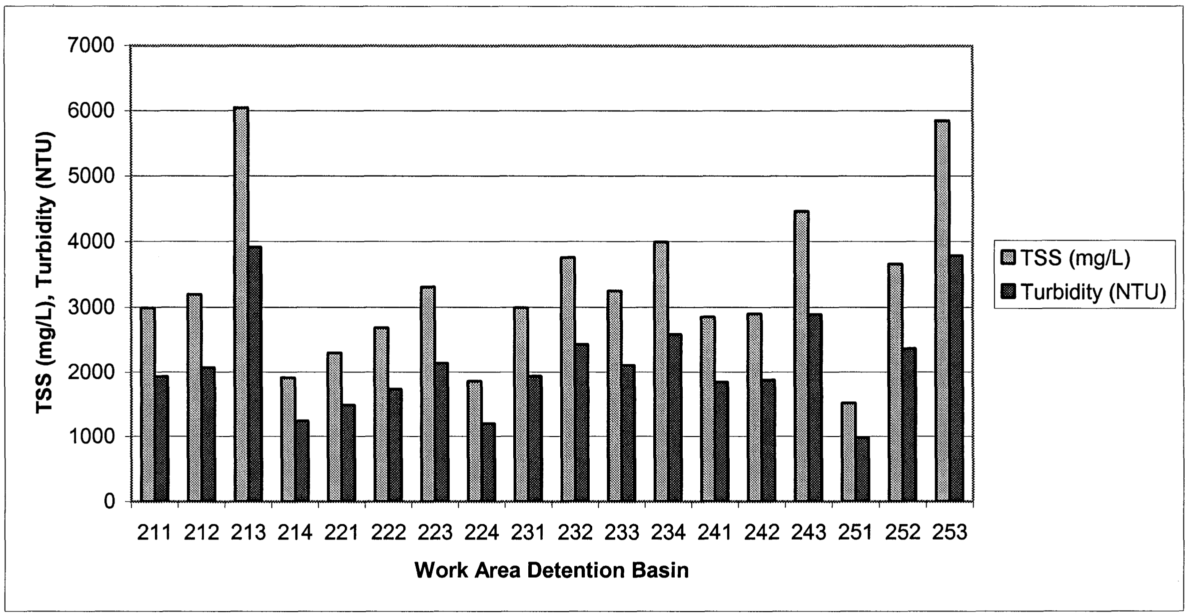


Figure 3
Predicted TSS concentration and Turbidity

3. Phosphorus Loading

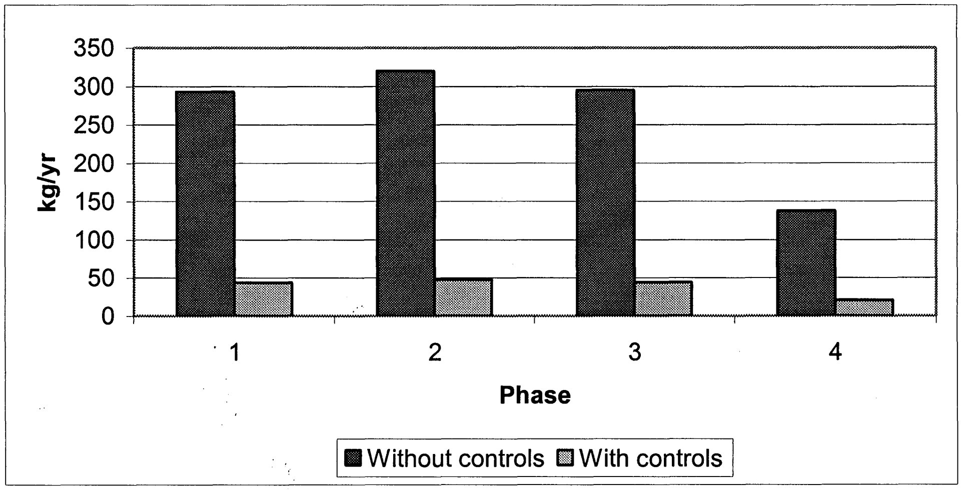
The annual phosphorus export during construction activities for Big Indian Plateau and Wildacres Resort has been determined in order to assess potential impacts to the Ashokan and Pepacton Reservoirs during construction of Big Indian Country Club and Wildacres Resort. The estimated impacts and mitigation measures are for worst-case conditions, which are calculated using rainfall of 30 inches for each subphase (i.e. all sequential disturbed areas of disturbance receive the precipitation for the entire construction season of mid April through the end of October). If a season rainfall distribution was utilized to calculate pollutant exports, such as Tannersville, 1993, which was used in WinSLAMM, pollutant export may be further decreased by as much as 1 order of magnitude because each subphase will only be in a disturbed state for 4 to 6 weeks. By utilizing annual rainfall for monthly precipitation, the estimations put forth herein are conservative in nature.

The Big Indian Plateau is located within the Ashokan Drainage Basin, which is split into two sub basins, the east basin and the west basin. The project site is located in the west basin of the watershed 20 miles upstream of the reservoir.

The Total Maximum Daily Load (TMDL) of a pollutant is used to assess the influent water quality to a waterbody. A TMDL is the cumulative loading that results from the sum of point sources (Waste Load Allocation), nonpoint source load allocations (Load Allocation), plus a margin of safety (MOS). The difference between the existing nutrient load and the TMDL is the unallocated loading, or the amount of nutrients that can be introduced to the watershed with out resulting in any adverse effects or exceeding the proposed guidance values in the reservoirs.

The proposed Phase II Phosphorus TMDL calculations for the Ashokan Reservoir have been established using the proposed phosphorus guidance value of 15 µg/L in the reservoir. The TMDL for the West Basin of the Ashokan Watershed is 45,399 kg-yr^{-1}. With the margin of safety (MOS) of 10% taken into account the TMDL is 40,859 kg yr^{-1}, of which 40,595 kg yr^{-1} is allocated to nonpoint sources (load allocation). The average total load (1993 – 1996) is 32,833. The watershed runoff is not fully yielding the entire load allocation of 40,595, therefore within the load allocation there is flexibility to reassign phosphorus loading since load allocation is not 100% utilized. The transferred phosphorus loading to the Ashokan Watershed is 8,026 yr^{-1}. Construction on the Big Indian Plateau is proposed to occur in four phases, over 4 to 8 years. The most significant impact associated with all four phases is anticipated to occur during Phase 2, year two, when construction activity will be the most intense. Accordingly, the greatest anticipated phosphorus load is 32 kg, which constitutes 0.4% of the transferable phosphorus load to the Ashokan Reservoir and is expected to be mitigated to operational phase phosphorus loadings. The annual yield of phosphorus from the Big Indian Country Club during Phase 2 construction is projected to be 32 kg. Figure 4 identifies the phosphorus loading from each work area during phase two of construction at Big Indian with and without the proposed construction stormwater mitigation controls as described previously in this Appendix of the DEIS. The anticipated phosphorus loading with the proposed mitigation measures in place constitutes 0.4% of the transferable phosphorus load to the Ashokan Reservoir for Phase 2 construction.

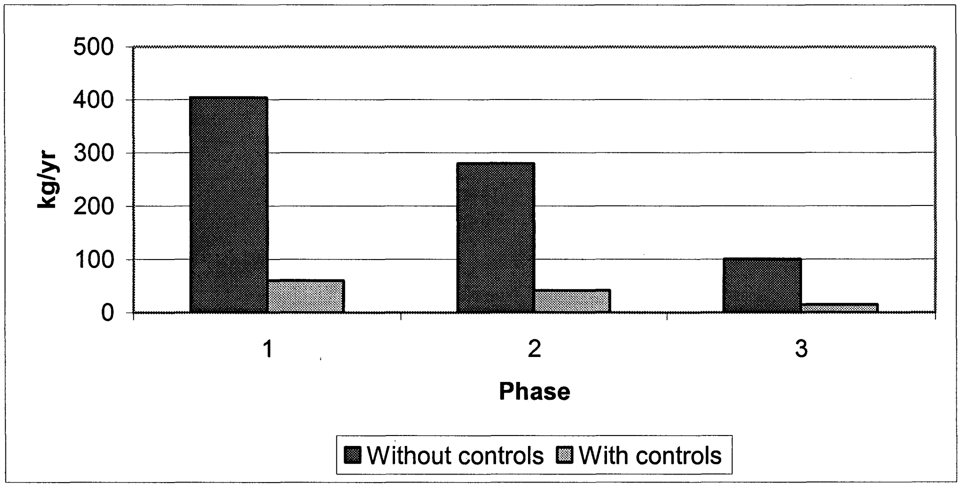
Figure 4
Big Indian Plateau Annual Phosphorus Yield (kg) During Construction



Wildacres Resort is located within the Pepacton Reservoir Watershed approximately 14 miles upstream of the reservoir. The proposed Phase II Phosphorus TMDL calculations have been established using the proposed phosphorus guidance value of 15 μg/L for the Pepacton Reservoir as well. Phosphorus TMDL for the Pepacton Watershed is 59,375 kg-yr^{-1}. With the margin of safety (MOS) of 10% taken into account the TMDL is 53,437 kg yr^{-1}. The average total phosphorus load (1993 – 1996) is 37,327 kg yr^{-1}. The unallocated phosphorus loading to the Pepacton Reservoir that is transferable to new nonpoint sources is 16,110 kg yr^{-1}.

Major construction at Wildacres is proposed to occur in three phases, over three years. Phosphorus export is estimated to be 40.4 kg during year one (Phase 1), 28 kg for year two (Phase 2), and 10.1 kg during year three (Phase 3) (Figure 5). The greatest anticipated phosphorus loading, during Phase 1, constitutes only 0.06% of the transferable phosphorus load to the Pepacton Reservoir.

Figure 5
Wildacres Phosphorus Loading

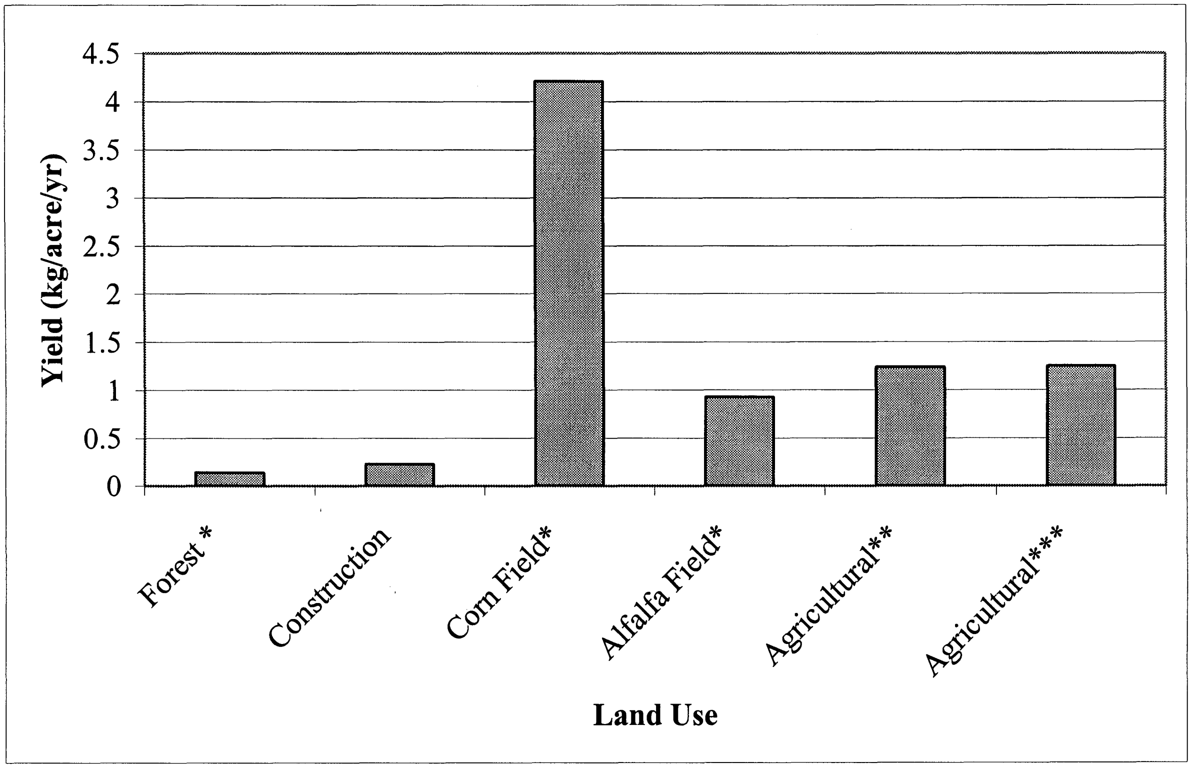


Phase 2 construction on the Big Indian Country Club will occur on ± 85.5 acres of disturbed land included in 139.42 acres of the Ashokan drainage basin. The balances of 53.92 acres in addition to the 85.5 disturbed acres are lands that are in construction subcatchments, but remain forested through the construction sequence. These forested areas are not disturbed during construction, but since they are in the same subcatchments they still contribute solids and dissolved nutrients to the stormwater detention basins. Thus, the per-acre-annual phosphorus loading is estimated to be approximately 0.23 kg per acre of "Active" construction area. Wherein, "Active" refers to lands that are undergoing construction activities and are a combination of disturbed soil, forest, stabilized, and impervious lands. The annual-per-acre phosphorus export for deciduous forested areas, as indicated in NYCDEP Phase II phosphorus TMDL calculations, is 0.14 kg per acre. The annual phosphorus export from the project site will increase from 0.14 kg per acre to 0.23 kg per acre during construction and return to pre-development levels using appropriate stormwater controls during operational phases, which are discussed in Appendix 10A of this DEIS.

The elevated phosphorus loadings that are expected during construction activities are significantly less than agricultural sources of phosphorus throughout the Catskill Watershed and other agricultural yield estimates obtained through literature surveys. The

NYCDEP utilized phosphorus export values to estimate phosphorus yields in drainage basins related to various land uses. Agricultural land uses were divided into three categories, alfalfa fields, cornfields, and barnyards. Phosphorus export coefficients were estimated to be 0.93 and 4.21 kg per acre for alfalfa fields and cornfields, respectively (Figure 6). Phosphorus yields from general agricultural lands, as obtained from the Wisconsin Department of Natural Resources and University of Minnesota, are 1.24 and 1.25 kg per acre per year, respectively, as shown in Figure 6, "Phosphorus Yields".

Figure 6
Phosphorus Yields



*New York City Department of Environmental Protection, 1999
**Wisconsin Department of natural Resources
***University of Minnesota

The phosphorus loadings that are expected during construction are closely related to loadings that would be expected from the operational phase. It is important to note that the phosphorus loading as a result of construction will occur for a duration of three years. The phosphorus yield expected during construction of the Big Indian Plateau is also significantly less than that of agricultural activities.

The calculated phosphorus exports from Big Indian Plateau and Wildacres Resort are both very small in comparison to the Watershed TMDLs and transferable loads for the Ashokan and Pepacton Reservoirs. The per acre export coefficients are intended to demonstrate land uses that would result in similar phosphorus yields. The phosphorus yield from the associated construction activities is less than what may be expected from agricultural land uses.

4. Additional Water Quality Improvements

The point at which construction stormwater quality has been assessed and presented thus far is prior to release via a spreader pipe. At this point, polishing of the stormwater effluent will occur in a fashion similar to overland flow treatment of wastewater. However, the clarified stormwater will have turbidity and nutrient concentrations that are far less than those associated with wastewater, which has been subject to numerous overland flow studies (Metcalf and Eddy, 1991; Reed et. al, 1988; Shahrezaie, H, 2001; USACOE, 1982, USEPA, 1981).

Overland flow uses physical processes to intercept pollutants and chemical and biological processes to degrade pollutants. Overland flow is a treatment option that is referred to by various names; Vegetated Buffer Strips, Forest Buffers, and Land Treatment Processes. Regardless of the name or title these systems improve water quality. Overland flow is best suited for use at sites having surface soils that are slowly permeable or have a restrictive layer such as a claypan at depths of 0.3 to 0.6 m (1 to 2 ft) (USACOE, 1982).

Overland flow is capable of achieving secondary effluent quality and high removal of N, BOD, and suspended solids (Biological Science Initiative, Virginia Tech). The USEPA (1981) indicates that treated water from land treatment processes are capable of producing average effluent suspended solids concentrations of 10 mg/l. This study was based upon screened wastewater applications and a slope length of 100 – 120 ft, which is far less that the slope lengths that are available on the proposed Project site. The TSS effluent concentration reported by the USEPA was confirmed by the work of Dialynas (2001), who reports effluent TSS concentrations of 10 – 15 mg/l after overland flow.

The New Jersey DEP, Center For Watershed Management, includes overland flow as a currently acceptable BMP. The Center indicates that TSS removal of a Riparian Forest Buffer is 70% and allows the incorporation of Forest Buffers in treatment trains to achieve the 80% TSS removal put forth by the USEPA. An overland flow site was found to remove 56.4 to 72.3% of TSS from primary wastewater effluent applications, 57.2 to 72.3% from final wastewater effluent applications, and 60-81.5% from industrial wastewater applications (Shahrezaie, H. 2001). The US Army Corp of Engineers observed suspended solids effluents of 8, 16, 5.2, 7, and 3 mg/l, for influent concentrations of 160, 185, 105, 59, and 47 mg/l, respectively (1982). The USACOE also notes that solids removal is unaffected by cold weather or changes in process loading. *The Architecture of Urban Stream Buffers,* Article 39 in the Practice of Watershed Management, indicates that a mature forest is the vegetative target for stream buffers.

Overland flow systems are variable in the treatment of stormwater. Performance can be enhanced by reducing contributing flow lengths to less than 150 ft, poorly drained soils and deep roots, extended buffer length, Organic matter, humus, or mulch layer, small runoff events, and entry velocities less than 1.5 ft/sec. Alternatively, buffer performance can be hindered by steep slopes (>5%), sediment buildup, tall grass, short contact times, contributing flow paths greater than 300 ft., and high intensity runoff events greater than

2-year storm events. Overland flow of wastewater treatment and disposal typically occurs on slopes less than 10%. However, the significant factor in determining overland flow feasibility is contact time rather than slope. Accordingly, overland flow may be employed on steep slopes if adequate slope lengths are available for suitable contact time.

The target effluent turbidity of the temporary stormwater basins is between 25 and 50 NTU. This equates to a TSS concentration between 38.6 and 77.2 mg/l. According to the NJDEP's 70% removal, the post overland flow concentration is expected to range from 11.58 and 23.16 mg/l. Literature reviews generally anticipate post overland flow concentrations between 10 and 15 mg/l. Hence, the overall range of TSS concentration that can be expected after overland flow is between 10 and 23.16 mg/l. Relating this TSS concentration to the site data and stream flow TSS/Turbidity data, the post overland flow turbidity is expected to be between 6.48 and 15.00 NTU. Since the target effluent is anticipated to be closer to 25 NTU, rather than 50NTU, the post overland flow turbidity is expected to be 6.48 NTU.

Terrain on which the overland flow applications will be constructed are typically on slopes ranging from 20% to 30%. The formula shown below is used to estimate overland sheet flow times. The formula was derived from previous work (Friend, 1954) in the form of a nomograph for shallow sheet flow over a planar surface.

$$t_o = (107*n*L^{0.333})/S^{0.2}$$

where,

t_o = overland sheet flow travel time (minutes)

L = overland sheet flow path length (m)

n = Horton's roughness value for the surface

S = slope of surface (%)

Note : Values for Horton's '*n* ' are similar to those for Manning's '*n* ' for similar surfaces. Values are given in Table 4.

Accordingly, the velocities of the resulting overland flow have been assessed to determine if erosive velocity would be problematic. The length and diameter of the dispersal pipes will be adjusted to release to achieve appropriately low entry velocities and to distribute the treated stormwater over a suitable forested area. The travel times were calculated using the Friends Formula, with a slope length of 500 ft and slopes of 20% and 30%. The resulting velocities were found to be 0.266 ft/sec and 0.288 ft/sec. Ultimately, it is not anticipated that the overland flow will result in erosive velocities when the entry velocity is sustained below 1.5 ft/sec.

Table 4
Values of Manning's 'n' for Overland Flow

Surface Type	Manning's n	Range
Concrete/Asphalt	0.011	0.01-0.013
Bare Sand	0.01	0.01-0.06
Bare Clay-Loam (eroded)	0.02	0.012-0.033
Gravelled Surface	0.02	0.012-0.03
Packed Clay	0.03	
Short Grass	0.15	0.10-0.20
Light Turf	0.20	
Lawns	0.25	0.20-0.30
Dense Turf	0.35	
Pasture	0.35	0.30-0.40
Dense Shrubbery and Forest Litter	0.40	

(MDID, 2001)

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