XVI. SUMMARY OF ADVERSE ENVIRONMENTAL IMPACTS RESULTING FROM OIL, GAS, SOLUTION MINING AND GAS STORAGE OPERATIONS

A. INTRODUCTION

This chapter summarizes the adverse environmental impacts from oil, gas, solution mining and gas storage operations. Analysis of the impacts on each resource will focus on normal operations conducted in accordance with Regulatory Program requirements. In addition, the potentially significant environmental impacts of accidents such as spills, leaks and blowouts will also be covered.

In assessing the impacts of proposed oil, gas, solution mining and gas storage activities, both long and short term impacts must be considered. Distinctions must also be made between impacts from single wells and less common multi-well projects such as underground gas storage fields. As previously defined, siting includes the planning, preparation and initial construction of a well site and access road. (See 8) Operations include drilling, completion, stimulation, reclamation, production, maintenance, and plugging and abandonment of a well. (See 9, 10, and 11)

The impacts on most environmental resources are very similar for all types of oil, gas, solution mining and gas storage operations. Therefore much of the discussion on the environmental impacts of standard oil and gas operations also applies to the other operations particularly with respect to siting and drilling activities. For other resources, however, the impacts from primary oil and gas wells, (See 8, 9, 10, and 11) waterflooding, (See 12) solution mining (See 13) and underground gas storage (See 14) must be addressed individually.

B. STANDARD OIL AND GAS OPERATIONS

For purposes of this section standard oil and gas operations will include any procedure relevant to rotary or cable tool drilling methods, and production operations which do not utilize any type of injection to facilitate the recovery of oil.

Most environmental resources are protected through siting restrictions and permit conditions. For example, streams can be protected through permit and siting restrictions on oil and gas wells near them. (See 6.B, 8.E.1, 8.G-H) Important groundwater supplies, agricultural lands, significant habitats, floodplains, freshwater wetlands, state lands and coastal areas can also effectively be protected through permit and siting restrictions. (See 6.C-G, I, K, and 8.E, F, J-N) Land, vegetation, and air, on the other hand, are everywhere and the utility of a siting restriction approach is limited. (See 6.H, J, M)

Noise and visual impacts will also occur wherever these operations are located. However, the significance of noise and visual disturbances is directly related to the presence of people and/or sensitive resources in the area. (See 6.N and 8.D.2) Therefore, these topics will be covered as warranted.

1. Adverse Land Impacts

The majority of the industry's activity centers on drilling individual oil and gas wells for primary production. (4.B.3)

Oil and gas operations vary in the amount of land used, their effect on local topography and volume of soil disturbed during construction operations but generally access road and site construction disturb less than two acres of land. Because of the minimum 40 acre spacing required for most new wells, impacts on landscape and soil resources are usually minor from the regional perspective. (See 6.H and 8.B)

a. Siting Impacts - Impacts associated with siting operations, are directly related to the location, size and contour of the well site. The impacts are virtually the same as those for other earth moving and construction operations. (See 8.A) The three main concerns are erosion, sedimentation and vegetation loss or damage. (See 6.H and 8.G-H) Compaction may also be a major concern in agricultural areas (See 8.F.2)

Erosion and sedimentation result largely from inadequate site preparation, such as poor grading or failure to install erosion control measures. (See 8.H) Some erosion and sedimentation is unavoidable when a site is constructed on or into a hill or slope but erosion and sedimentation can be controlled through efficient reclamation operations. (See 10.B and 11.E.1)

Vegetation losses are unavoidable. (See 8.A) Nearly every site must be stripped to the hardpan clay zone to avoid more severe erosion and sedimentation problems. Long-term vegetation losses on a site are most severe when an operator fails to properly segregate topsoil from other excavated material. An increasing number of operators have realized the importance of topsoil preservation over the last three to five years. As a result, revegetation of well sites has improved. (See 8.D.2.b, 8.F.3, 10.B and 11.E.1)

Potential long term impacts from soil erosion are a serious concern. (See 8.H) Topsoil takes hundreds of years to form and its loss can have serious long term impacts on the land's ability to support crops and other vegetation. (See 8.F.3) Persistent erosion can also result in significant changes in the landscape.

Under the existing Regulatory Program, erosion control measures are only specifically required for wells in watersheds of drinking water reservoirs. (See 6.B and 8.H.1) Permit conditions addressing erosion control during construction can be applied to wells outside the watersheds, when they are needed. (See 8.H.2)

The potential for accelerated rates of erosion continues long after the construction activities are completed. (See 10.B) The current regulations do not specifically require that the topsoil be set aside and redistributed, or that disturbed areas be seeded and mulched except where other DEC permits are required in environmentally sensitive areas, such as Agricultural District lands or wetlands. (See 6.F, 6.I, 8.F.3 and 8.L) Therefore, the adequacy of the site reclamation plan is sometimes left to the operator's discretion and/or the provisions of the lease agreement. (See 8.F.5) Failure to skim off and set aside the topsoil layer can result in its burial during site reclamation, effectively sterilizing surface soils. (See 8.F.3, 11.E.1)

b. Operational Impacts - The existing regulations also do not address the need for partial site reclamation between the drilling and production phases of a successful well. Producing wells and their associated facilities usually cover only 10 to 15 percent of the original drill site. (See 10.B.1, 10.B.2) Operators are only required to remove waste fluids from drilling pits within 45 days after the cessation of drilling operations. (See 9.H.8) Conscientious operators immediately reclaim the pits and the other portions of the well site that are not needed to support production operations so that the land can be returned to productive use thus preventing soil erosion. If this partial reclamation is not undertaken, soil erosion and other associated problems may continue throughout the producing life of the well (30+ years) and have serious long term negative impact on soil and land resources. (See 6.H, 8.H, 10.B)

c. Fluid Handling Impacts - Negative environmental impacts on soil resources can also result from accidental spills of oil, brine or other materials involved in drilling and production of oil and gas wells. Depending upon the type and amount of material spilled, the contaminated soil may be unable to support vegetative growth. Brine and other waste fluids high in salt can kill vegetation and retard growth for years. (See 9.H.7.a) Similarly, oil spilled on the ground surface can kill plants and retard new growth. (See 10.B.2.a)

2. Adverse Impacts On Other Environmental Resources

The potential environmentally negative impacts on agriculture, significant habitats, floodplains, freshwater wetlands, state lands, coastal areas, air quality, social and cultural resources, archeological resources and flora and fauna are summarized below.

a. Agriculture - Siting Impacts - The major negative impacts on agriculture are damage to soil resources and long term occupation of agricultural lands by non-agricultural activities. (See 6.H-I and 8.F)

Lands in Agricultural Districts are less likely to suffer serious negative impacts because proposals affecting Agricultural Districts are subject to more detailed environmental review under SEQR. However, a substantial portion of the State's agricultural lands still lie outside these districts. Siting of oil and gas wells and their associated facilities can have serious long term impacts on agricultural operations. Construction may remove viable farm land from production, bisect tillable fields and interfere with basic farming operations. (See 8.F.2) Construction of access roads and well sites can also damage tile drainage systems or interrupt natural drainage. (See 8.F.1) Lease agreements between the landowner and the operator should, but do not always, address these problems. (See 8.F.5)

Damage to topsoil during the construction phase can take three forms: compaction, burial or erosion. (See 6.H, 8.F.3 and 8.H) Topsoil may be buried beneath sterile subsoil either during construction and/or reclamation procedures. (See 8.F.3, 10.B and 11.E.1) It may also be lost through erosion that starts through poor siting and construction techniques. (See 8.A and 8.H) These negative impacts are most likely to occur outside of Agricultural

Districts and watersheds of drinking water reservoirs where erosion control measures are not required on a consistent basis. (See 8.F and 8.H.2)

Operational Impacts - Impacts on agriculture from drilling are generally related to handling waste fluids. (See 8.F.3-4 and 9.H) The high salt content of most waste fluids can kill vegetation and retard growth for years. (See 9.H.6.a,c,e-g and 9.H.7.a) Mildly acidic wastes can also contaminate soil and increase mobility of heavy metals. (See 9.H.6.d. and 9.H.7.d) Wastes are generally stored on site in pits or tanks prior to final disposal and operators are required to have sufficient storage capacity on site to handle them. (See 9.H.1-5) Accidental spills sometimes occur, especially in the immediate vicinity of the holding pits. (See 8.D.1 and 9.H.2-3) The extent of the impacts on soil resources and agricultural operations will depend on the composition of the waste, the volume spilled, the natural attenuating capabilities of the soil, and the success of cleanup operations. (See 9.H.6-7)

Open access to an unreclaimed well site can also adversely affect livestock who may wander out of their pasture and onto the site. Livestock illness or death can result from ingestion of waste fluids. (See 8.F.4-5)

Impacts on agriculture from production operations are generally related to the long term use of agricultural lands for non-agricultural purposes, from short-term site construction activity and from accidental spills of oil or production brines which may contaminate the soil resource. The land occupied by the well, access road, and production facilities may not be available for agricultural uses for several decades. (See 10.B)

b. Significant Habitats - Significant habitats are areas which "provide some of the key factor(s) required for survival, variety, or abundance of wildlife, and/or for human recreation associated with such wildlife". (See 6.K and 8.J)

Negative impacts from oil and gas activities on significant habitats are uncommon because the habitats are relatively small and scattered. Inventorying of significant habitats is an ongoing project so the possibility exists that a sensitive and ecologically important area will be unknowingly disturbed. (See 6.K, 8.J and 8.N.2)

c. Floodplains - Floodplains are the lowland areas along streams, rivers, ponds and lakes which carry extra water when heavy rain or melting snow causes a waterbody to overflow its normal banks. Property damage and other problems can arise when development of any kind takes place in these areas. Well siting and construction in floodplains destroys vegetation and changes the topography which can interfere with the water carrying capacity of the floodplain. (See 6.G and 8.K) Removal of vegetation from floodplains can lead to erosion and sedimentation problems. Erosion could be particularly severe during a flood resulting in sedimentation of adjacent waterbodies. (See 8.K.5)

Flooding is likely to occur sometime during the producing life of a well located on a floodplain. If the floodwaters reach the well site, oil and production brine tanks will usually be held in place by their anchors. (See 8.K.2-3) However, debris carried by the flood could conceivably rupture a tank, and spilled oil carried by floodwaters could result in damage over a significant area. (See 8.K.4 and 10.B.2.a)

d. Freshwater Wetlands - Wetlands smaller than 12.4 acres are not covered by the provisions of the Freshwater Wetlands Law unless they have unusual local significance. The addition of conditions to drilling permits to protect smaller wetlands is done on a sporadic basis depending upon the known value of the wetlands and the availability of alternate sites. (See 6.F and 8.L)

Construction of access roads and well sites in wetlands results in destruction of vegetation, changes in landscape and water levels, and loss of plant and animal habitat. (See 8.L.1-4) These alterations in turn can negatively affect the ecological balance of wetlands and the benefits they provide. (See 8.L pp 8-41, 8-42) Impacts from drilling oil and gas wells in or near wetlands are generally related to handling of waste fluids. Accidental discharges of these waste fluids to wetlands can kill trees and other vegetation, sterilize the soil and permanently affect the nature of the wetland habitat. (See 8.L.8)

e. Coastal Lands - Impacts of oil and gas activities on coastal lands will vary greatly depending upon the exact nature of the coastal area involved. For example, even minor visual disruption near coastal wetlands or popular recreational areas may be regarded as an extremely negative impact. On the other hand, in coastal farming areas, topsoil loss and other agricultural concerns may be the most important negative impacts. (See 6.E and 8.N)

Because of the many competing water-oriented uses of coastal lands, the State Legislature passed the Waterfront Revitalization and Coastal Resources Act (WRCRA). WRCRA requires maintenance of a balance between economic development and preservation of the State's unique coastal resources. Policies for maintaining this balance are detailed in the State Coastal Zone Management Plan and individual Local Waterfront Revitalization Plans. All proposed oil, gas and solution mining activities must be consistent with these plans. Therefore, any potential negative impacts of proposed oil, gas and solution mining wells on coastal resources will be fully considered before a decision is made on issuing a permit. (See 6.E and 8.N)

f. State Lands - Oil and gas drilling on DEC controlled State lands is primarily restricted to State Reforestation and Game Management areas where land use conflicts and disruption of recreational activities will be minimal.

(See 6.D and 8.M) Environmental impacts on State lands are controlled through temporary revocable State Lands Permits in areas not covered by oil and gas leases. Permit conditions are not usually required on State Leases because stipulations are written directly into the lease which address environmental concerns and ensure that the primary designated use of the State Land will continue unhindered. (See 8.M.1)

The New York State Office of Parks, Recreation and Historic Preservation (OPRHP) serves as the lead agency for SEQR Review of drilling permits under a Memorandum of Understanding with DEC. Therefore, when drilling permit applications are received for wells in State Parks, they are forwarded to OPRHP. This system ensures that any negative impacts of oil and gas development on State Parklands will be handled by the State Agency most familiar with the Park system. Current statute prohibits any future leasing of State Parklands. (See 6.D and 8.M.2)

g. Air Quality - Most air quality impacts associated with oil and gas, solution mining and gas storage operations are usually short-term and minor. (See 6.M) The primary air contaminants that may occur are: 1) oil distillate from production facilities, (See 10.B.2.a) 2) airborne dust from construction activities and/or traffic on unstabilized access roads, (See 8.D.1) 3) diesel fumes from equipment operation (See 8.D.2) and 4) uncommon accidental uncontrolled flows of methane and H_2S. (See 9.A.4 and 10.B.1.a)

Dust and exhaust fumes from heavy equipment are the most common air quality impacts that occur from siting. Like most other small construction sites, the associated dust and exhaust fumes are short term and limited in areal extent. (See 8.A and 8.D.1)

In the worst situation where an accident results in an uncontrolled natural gas flow, air quality can be very negatively impacted. Uncommonly small amounts of hydrogen sulfide (H_2S) have been noted during drilling in New York. (See 9.A.4) Both situations pose extreme health and safety hazards. Such releases must be controlled immediately. Gas releases are generally regarded first as an immediate safety concern, with the philosophy that once the safety situation is corrected, health and environmental hazards can be evaluated. (See 10.B.1.a)

The most common air quality problems, during the well production phase, originate from oil stock tanks. Distillates and fumes escaping from improperly vented stock tanks are readily recognized by offset landowners or by anyone frequenting the area. (See 10.B.2.a)

Venting of wells which is only allowed in the old oil field areas where gathering of the limited associated gas is not economic, will cause localized degradation of air quality. (See 12.C.2.b) Gas leaking from wellheads can cause safety concerns if trapped in an enclosed area. (See 10.B.1.a)

h. Social and Cultural Resources - People are the primary social and cultural resource in the vernacular of environmental impact statements. This section covers direct impacts on people. Siting of wells too close to areas inhabited or frequented by people unnecessarily exposes them to possible accidental injury. Although no problems have been recorded to date, staff analysis of the existing siting restriction on wells near private dwellings shows that the residents and their property might not be adequately protected by a 100' buffer in the event of a well blowout or fire. (See 8.D)

Compared to the drilling phase, the safety concerns associated with production are relatively minor. For this reason, the siting of production equipment is not covered under the existing surface restrictions. However, in heavily populated areas and/or areas frequented by children, the Department can require that access to the site be restricted. For example, fencing around a pump jack may be required for a well on school grounds. Restricting access to production equipment may also be necessary to prevent vandalism. Although such instances are rare, vandals tampering with the valve on a production tank have been credited with an oil spill that reached a nearby river. (See 8.D and 10.B)

Production facilities can have long term visual impacts. The visual impacts from gas wells are generally minor because of the small size of gas production facilities. (See 6.N, 8.D.2.b and 10.B.1) The storage tanks associated with oil wells, however, can be visible for a considerable distance. The extent of the visual impacts in a particular instance would depend on the size of the production tank, its proximity to nearby residences, public buildings, areas or roads, surrounding land uses, local topography, type of vegetation, and the presence of man-made objects that serve as visual barriers. (See 6.N, 8.D.2.b and 10.B.2)

Noise impacts from production facilities are generally minor but drilling operations are quite noisy. Drilling operations usually continue 24 hours a day, so people living in close proximity can be very uncomfortable. Fortunately most wells are drilled within a week, and rig sound proofing or restricted drilling hours could be added as special permit conditions under special circumstances. (See 8.D.2.a-b)

i. Historic and Archeologic Resources - Impacts on historic sites from construction of the access road and well site are generally very minor. Depending upon the individual circumstances, DEC may require a change in the proposed well location, visual screening of construction activities, or restrictions on hours of operation. (See 6.L and 8.I)

The impacts of construction activities on archeologic resources are more serious. Since archeologic sites are generally difficult to detect by their surface appearance, they are more likely to be damaged during construction.

Even if artifacts are salvaged before excavation begins, removal from their original location and disturbance of the site will destroy much of their value. Even with safeguards, it is possible for an archeologic site to escape detection until construction actually begins. When this occurs, conscientious operators cease construction and notify the Department of their discovery. (See 8.I.2)

j. Flora and Fauna - Impacts on flora are similar to those described under land impacts. Impacts on specific flora vary greatly. When a mature tree is removed, certainly it will take decades to replace it. Conversely, natural field vegetation, such as goldenrod, ragweed, queen-anne's lace and tiger lily, will replenish itself within one growing season. Endangered or protected species of flora are often located in rugged and/or sensitive terrain areas such as stream banks, wetlands or gorges. Protection of such flora is stipulated in the permits for wetland or stream crossing construction activity. (See 8.G and 8.L)

Fauna are temporarily displaced during every facet of oil and gas operations except production. Drilling, completion, reclamation, maintenance and plugging and abandonment operations require heavy equipment and manpower. Heavy equipment agitates wildlife, forcing the wildlife to relocate. During the production phase of a well, on site activity is minimal and wildlife such as deer, turkey, rodents, reptiles and amphibians are quite often seen near the well site. Permanent disruption of fauna/habitat is rare due to the small size of the site after reclamation. (See 6.K and 8.J)

3. Adverse Impacts On Surface Waters

a. Siting Impacts - Impacts on surface waters from routine oil and gas activities are generally minor. (See 6.B, 8.E.1, 8.E.3.a) Most siting impacts are short term or temporary in nature and can be mitigated or avoided. However, the potential exists for adverse impacts when conducting operations near surface waters. Most impacts on surface waters from siting operations occur during the initial construction period of the well site and access road. (See 8.A) The major concerns are turbidity, sedimentation and erosion. (See 8.G-H)

Sedimentation by eroded soils is the most serious surface water quality concern during the well site construction phase. While turbidity is often a short term problem, if the conditions responsible for erosion and subsequent sedimentation persist, or become more intense, continued turbidity will occur. Serious soil erosion and sedimentation are more likely to occur when: 1) a site is prepared during the wet season or, 2) an inordinate amount of precipitation washes out the site. (See 8.H)

On a large scale, sedimentation and turbidity may reduce the oxygen in surface waters which in turn may have a significant effect on resident flora and fauna. Heavy sedimentation can adversely affect spawning grounds and, in extreme cases, re-route a stream. The affected bodies of water often require mechanical assistance, such as dredges, filtering devices, etc., to correct the problem. (See 8.H) Surface waters most sensitive to siting impacts are reservoirs and their feed streams. Heavy sedimentation in a watershed can lead to a shutdown of a public water supply. When these potential problems are recognized prior to permitting, specific requirements are stipulated on the permit, thereby averting or minimizing impacts. (See 8.H.1-2)

Lack of adequate erosion and sedimentation controls and negligence or accidents are the major sources of detrimental turbidity conditions. Examples of three major types of negligence and their possible consequences are:

Condition	Result
1. Improper culvert pipe size	Allows stream to back-up, washing the bank soil into the stream
2. Poor site or access road preparation	Allows sediment to escape from site into a body of water
3. Substandard workmanship	Improper culvert installation allows a stream to washout embankments and flow around the culvert pipe carrying eroded soil

b. Operational Impacts - There are few adverse impacts on surface waters from drilling operations conducted in accordance with regulatory requirements but accidents, such as spills of drilling waste fluids can have serious water quality impacts. (See 9.H.6-7) Increases in chlorides, heavy metals and organic compounds as well as changes in pH can occur. Depending upon the concentration of the waste fluids and the characteristics of the receiving waters, a fish kill may also occur. Adoption of the proposed increase in the 50 foot siting setback on wells near surface water bodies will lessen the chances of negative impacts should a spill occur. (See 8.E.1) Accidents cannot be forecasted. However, accidents and their impacts can be minimized through sound engineering techniques, strict adherence to safety precautions and prompt remedial action, when necessary. (See 9.A.4)

Drilling waste pits if not properly sized or constructed can overflow or cave-in allowing fluids to escape. An adequately sized pit can also overflow due to inordinate amounts of precipitation, lack of sufficient means of diverting surface runoff, sudden winter thaws or an encroaching water table (reducing the pit's capacity). (See 9.H.1-3)

Completion operations are conducted after the hole has been drilled. (See 10.A) Improper containment of the frac fluid is the most common source of pollution in the completion phase. If fluids are not properly handled, surface waters may be adversely affected by run-off from spills containing the chemicals used in the fracturing process. (See 9.F)

Site reclamation, by definition, is a restoration process. Improper reclamation techniques can lead to pit overflows and accelerated erosion due to poor grading and/or lack of seed and mulch. (See 8.F.3, 10.B and 11.E.1) All of these conditions can degrade surface water quality.

c. Fluid Handling Impacts - Surface water impacts associated with production are largely the result of accidental leaks of production lines or overflows of brine and oil tanks. (See 8.G.2, 10.B.2) Accidental spills of oil or production brines can result in potentially serious water quality impacts if the spill reaches the surface water body. Like drilling waste fluids, production brines, can cause fish kills and localized, short term changes in water quality. (See 9.H.6.f, 9.H.7.a, 10.B.1.a, 10.B.2.a) Spilled oil can have greater environmental impacts because it can be transported large distances on surface waters and persists in the environment. Waterfowl and other wildlife downstream from the spill can be "oiled" and die of exposure. Vegetation and soils along the banks of the waterbody may also be subjected to long-term oil contamination. In addition, weathered oil which will sink to the bottom of a waterbody can negatively affect benthic organisms and become permanently entrained in the substrate. (See 8.K.2 and 10.B.2.a)

Another, less common, occurrence associated with production are those wells from which fluids leak and contaminate local surface waters. (See 10.B.1.a and 10.B.2.a) Well maintenance operations can also have an impact on surface waters in the form of brine spills. These are usually the result of the maintenance crew's failure to contain fluids during "flowback" or "swabbing" operations. (See 9.F.3)

4. Adverse Impacts On Groundwater

Groundwater protection is a major focus of the Department's Regulatory

Program because over one-third of the State's drinking water is currently supplied by groundwater. (See 6.C, 8.E.2, 8.E.3.b-c, 8.E.4) Groundwater is also much more vulnerable to contamination than surface waters. Dilution of pollutants in surface waters is aided, to varying degrees, by the volume of the waterbody and its rate of flow. However, water moves much more slowly underground, inhibiting mixing and dilution of contaminants. Breakdown of pollutants is also inhibited by the absence of oxygen and normal surface weathering processes. (See 8.E.3.b)

a. Siting Impacts - Siting construction operations rarely impact groundwater supplies except when a surface water is hydrologically connected to a groundwater supply. Even then, intrusion of pollutants from surface waters is rare for a number of reasons: 1. surface contamination is easily recognized and can be corrected before groundwater is affected, 2. surface waters will dilute contaminants, and 3. the communication channels from surface waters to groundwaters provide a natural filtering network. Near surface groundwaters, such as springs are the most commonly impacted groundwater supplies. Turbidity most commonly results when siting operations disturb a spring. However, such impacts are usually temporary in nature providing the operator adheres to sound reclamation procedures. (See 8.E.2)

Siting oil and gas wells in primary aquifers and/or near municipal water supply wells can increase the chances for contamination of important groundwater supplies. Therefore, special restrictions are placed on these wells. (See 6.C, 8.E, 8.E.3.b-c)

b. Operational Impacts - Potential groundwater impacts associated with standard oil and gas operations are interrelated and complex. When groundwater contamination is discovered, and its source determined and corrective actions applied, the problem can still persist for years. Parameters such as the type of pollutant, aquifer characteristics, the specific source which contributed to the problem, and the nature of the problem itself all play important roles in the duration of contamination.

Turbidity can occur, while drilling the surface hole. When a groundwater supply is penetrated, disturbance can allow sediments to enter the water supply and create offset turbidity if a subsurface channel of sufficient porosity and permeability is present. If the surface hole is drilled with a proper drilling fluid, a filtercake will develop and isolate the wellbore and only minor turbidity could occur from filtration of the drilling fluid a few feet into a permeable aquifer. Cement can also filtrate into permeable aquifer zones if adequate lost circulation material is not used during cementing operations. The majority of these situations are temporary, and usually correct themselves in a short time. In isolated cases, water wells can cave-in or permeable water channels can be intercepted and re-routed, adversely affecting a water well's quality and quantity of water. In serious cases, the drilling of a new water well may be required. (See 9.C)

Adverse impacts on groundwater due to stimulation operations are usually the result of improper fluid handling. Where prudent measures are taken to contain flowback fluids and/or maintain pit integrity, problems are rare. However, contaminants may percolate into groundwater supplies if stimulation fluids are not contained. (See 9.F and 9.H) The shallower the waterbearing formation the greater the pollution potential from surface disturbances and contamination.

Several negative influences on groundwater supplies can appear during the production phase of a well. The majority of these problems are actually the result of inadequate drilling or casing and cementing operations which do not manifest themselves until the later production stage of the well. (See 10.B.2.a)

The majority of negative groundwater impacts can be attributed to inadequate cementing procedures on the surface (freshwater protection) casing. (See 9.C) Other problems, such as gas channeling through the cement before it has set, can produce micro-annular fissures or cracks which create a conduit for gas and other pollutants to escape from the formation and migrate directly to the surface and/or into a potable water supply. (See 6.C, 8.E, 9.C)

When the production casing cementing operations are inadequate, gas will enter the uncemented annular space or channel through micro-annular cracks caused by shrinkage of the cement as it sets and be detectable at the surface. (See 9.C, 9.E) Lack of cement across a gas bearing formation can lead to pressure increases in an unvented annulus which in turn may cause breakdown of shallower formations and allow the gas to migrate into other zones of lower pressure, some of which may be water bearing. Since gas follows the path of least resistance, depressurization of the gas at the surface through venting can alleviate this problem. (See 10.B.1.a)

Oil and brine can also migrate from wells which do not have integrity. If the problem is due to a failure in the tubing or production string, losses in pressure and production volume will indicate that remedial action is required. If migration is from an uncemented hydrocarbon bearing formation behind pipe, the problem can be detected by annular inspections. If the annulus is opened and the zones have sufficient pressure, oil and/or brine may flow to the surface. However, most formations in New York do not have enough pressure to bring a column of fluid to the surface. Instead, a column of fluid will develop to a specific height above the pressured formation. When the pressure exerted by the column of fluid equals the pressure of the producing formation, a static equilibrium develops. The depth of this subsurface fluid column may equal the depth of a freshwater zone and if the freshwater zone is not protected by surface casing, the oil or brine fluid column can enter the freshwater zone. Under these conditions, the source of contamination may not be recognized especially if it is from an improperly abandoned well. (See 10.B.2.a)

c. Fluid Handling Impacts - Additional groundwater impacts can result from the spillage of produced fluids. The majority of spills are the result of storage tank failures. Leaks, valve malfunctions, improper maintenance and vandalism are other spill sources. Oil contamination of groundwater as a result of surface spills will occur when they are not cleaned up and there is sufficient time and volume for the oil to percolate. (See 10.B.2.a) Shallow groundwater supplies such as springs can be impacted quite severely by a nearby oil or brine spill. (See 8.E.2)

5. Plugging and Abandonment Impacts

When plugging and abandonment of oil and gas wells is done properly, there are no major adverse environmental impacts. There are minor impacts such as dust and exhaust fumes from heavy equipment, (See 8.D.2.a) but these negative impacts can be mitigated by speedy and adequate site reclamation. (See 10.B and 11.E) Plugging and abandonment operations only impact surface waters (See 6.B and 8.E.1) when existing reclamation regulations are not followed. Ongoing sedimentation problems may occur if site restoration is delayed or disregarded. (See 8.H)

The well plugging stage is a crucial one in terms of groundwater quality protection. (See 6.C, 8.E.2, 8.E.3.b-c, 8.E.4, 11.A and 11.H) Potential impacts on groundwater are related to plug location, plug length and plug integrity. Overall, the Department's regulation of plugging and abandonment procedures minimizes the chances of groundwater pollution. However, recommendations have been made to improve plugging procedures and further reduce the chance of groundwater pollution by oil, gas, brine or other contaminants. (See 11.F-G)

Since the entire wellbore is a potential channel for fluid movement, wells must be plugged with cement at several locations and the intervals in between must be filled with an approved fluid. (See 11.A) These plugging requirements are generally considered sufficient to protect groundwater quality. However, accurate plug placement is difficult to ensure unless the well is re-entered to tag the plug after it sets to check its location. (See 11.F.1.a, 11.F.1.d, 11.F.1.f, 11.F.2.a, 11.G.3.a-b, 11.G.4.b, 11.G.8.a) Inadequate plugging and abandonment of oil and gas wells can cause severe environmental problems. Migration of well fluids into permeable zones can occur if 1) plugs are not set at correct intervals, 2) inadequate size plugs are used, 3) improper cement is used for plugs and 4) inadequate fluid is placed between the plugs. (See 11.A, 11.B.3, 11.C, 11.F-G) "Weak" plugs can also result from cement contamination excessive mix water, and gas channeling. (See 11.D and 11.F) If any of these problems occur, the current required 15' length of the cement plugs does not provide sufficient groundwater quality protection.

Well fluids which migrate and escape from improperly plugged and abandoned wells pose the same negative potential impacts as a well with uncemented oil and gas zones. (See 9.C, 10.B.1.a, 10.B.2.a, 11.A) Adequate plugging and abandonment of wells is the most critical operation for long-term environmental protection.

C. ENHANCED OIL RECOVERY IMPACTS

1. Siting and Operational Impacts

Enhanced oil recovery operations require more intense land use than standard oil and gas operations. Oilfield waterflood operations generally involve a minimum of five wells (4 injector wells and 1 producer). However, most waterflood permit applications are for the addition of individual wells to existing fields and projects. The five-spot pattern can be extended into a new area with a single well by converting nearby wells to injectors or producers, as needed. (See 12.C.1)

From a regional perspective, waterflood operations have some unique considerations. Waterflooding is presently confined to the State's old oil fields where development dates back to the 1800's. (See 5.C.4.e and 12.C.2) Because of historic drilling practices in these areas, the old wells are closely spaced (roughly 2½ to 5 acres per well) making 40 acre spacing for new wells impractical. (See 8.B.1 and 12.C) Therefore, new waterflood wells are more densely spaced than primary oil and gas wells and continued development of waterflood operations can be expected to have more noticeable localized land use impacts. (See 12.C.1 and 12.I)

In addition to erosion, sedimentation and vegetation damage associated with any construction, New York waterflooding operations have other unique impacts. There are many brine discharges from separator ponds which empty either directly into a stream or across a stretch of land to a stream. Impacts from these discharges include vegetation damage, potential contamination of soil, minor erosion, and stream habitat pollution. (See 12.I)

Other potentially significant adverse impacts include soil contamination from oil leaking from stock tanks and wellheads. (See 10.B.2.a) Land-use losses occur more frequently due to the higher concentration of well sites, access roads, injection facilities, separator ponds, tanks and pipelines required for waterflooding. (See 12.C.1 and 12.I)

2. Surface and Groundwater Impacts

The major impacts from EOR operations are those related to groundwater. (See 6.C, 8.E.2, 8.E.3.b-c, 8.E.4) All of New York's waterflood areas were established prior to regulation and many of the wells still in use are over 50 years old. (See 4.B and 5.E) Most wells have inadequate cement or no cement at all, which provides a conduit for pollutants to enter potable water supplies. The old casing in these wells routinely fails due to age and exposure to a corrosive environment. (See 4.D and 12.C.2.a)

Of most concern, are the locations of thousands of unknown deserted or abandoned wells which may or may not have been properly plugged. (See 11-A and 12.C.3) An improperly plugged well will provide a conduit for pressurized fluids to migrate and endanger water supplies. (See Chp. 11 and 10.B.2.a) Waterflooding increases the potential for groundwater quality impacts because it provides pressure to areas which no longer have sufficient pressure for production or fluid migration (See 12.C.2.c) and most waterflood wells are older in age and were drilled and completed to less stringent standards. (See 12.C.2.a) In addition, most of the unplugged, unmapped abandoned wells are located in the State's old waterflooded areas. (12.C.3)

Impacts on surface waters from site construction, drilling and plugging and abandonment of waterflood wells are the same as those for primary oil wells. (See 6.B, 8.E.1, 8.G-H, 9.F.3, 9.H.6-7, 10.B.2.a, 11.A, 11.E.1) The major differences in impacts are attributable to the production phase when production brines are discharged to surface streams under a SPDES Permit. Impacts from discharges to surface waters are minimized by the conditions in SPDES permits regulating waste composition and discharge rate but minor increases in chlorides, oil, grease, as well as benzene, xylene and toluene levels may occur in the immediate vicinity of the discharge point. Significant localized effects on the quantity and quality of aquatic life have been observed. (See 9.H, 12.C, 12.I, 15.D.2)

D. SOLUTION MINING IMPACTS

There are five solution mining facilities currently operating in New York

State and wide variations exist in their number of wells (4-170), and the acreage mined, owned or held under lease (1,000 to 4,000 acres). Like waterflood operations, solution mining operations are usually developed in phases and permit applications are generally submitted for one or two wells at a time. (See 13.A)

1. Siting and Operational Impacts

Aside from the potential disturbance of a larger land area, siting impacts of solution salt mining wells are essentially the same as standard oil and gas wells. However, production operations have different potential environmental impacts. Spills which impact surface water, groundwater, and land (including flora and fauna), are more likely to occur because of the corrosive nature of the product (large volumes of highly concentrated brine). (See 13.N-O) Accidental leaks of concentrated brine can kill vegetation, percolate into groundwaters, contaminate the soil and retard growth for a long time. (See 9.H.7.a) Corrosion of casing is also of concern, since groundwater resources potentially can be adversely impacted. (See 13.I-J)

Land subsidence is another major concern resulting from solution salt mining operations. Land subsidence can have long term impacts on land use. Solution mining creates large underground systems of cavities and if the location and extent of these cavities is not carefully controlled, the overlying formations become unsupported and ground subsidence may occur. More severe subsidence will occur when the overlying bedrock is thin between the salt formation and the surface. The subsidence can fracture the bedrock above the cavern and form channels for the movement of brine into fresh ground water supplies. Subsidence problems can create "mud boils", damage surface structures, and seriously impact the economic value of the land. (See 13.K)

Subsidence and its secondary impacts may go undetected because the existing Regulatory Program does not require monitoring of ground elevation for solution mining operations. Some operators, however, have voluntarily undertaken extensive monitoring programs. (See 13.K)

2. Surface and Groundwater Impacts

Impacts on surface waters from site construction, well drilling and plugging and abandonment are similar to those for oil and gas wells. (See 6.B, 8.E.1, 8.G-H, 9.F.3, 9.H.6-7, 10.B.1.a, 10.B.2.a, 11.A, 11.E.1) If a brine spill does occur, the chances of chloride contamination of a nearby surface waterbody are higher because of the large volumes of highly concentrated brine present at solution mining operations. (See 9.H.7.a)

The impacts of solution mining wells on groundwater (6.C, 8.E.2, 8.E.3.b-c, 8.E.4) are significantly different from oil and gas wells because of the: 1) general absence of hydrocarbon production, 2) the large volumes of highly concentrated brine involved, (See 9.H.7.a and 13.N-O) 3) the strongly corrosive nature of brine (See 13.I-J) and 4) the greater tendency for land subsidence over solution mining cavities. (See 13.K)

Subsidence may cause fractures in the subsurface strata which provide channels for the movement of brine into underground freshwater supplies. Subsurface fractures may also be a conduit for the movement of freshwater into salt cavities leading to further cavity growth and subsidence. (See 13.K)

Negative impacts on groundwater are also associated with deserted, unplugged wells. (9.H.7.a, 11.A and 11.H) Without proper plugging, freshwater from rain and surface run-off can also enter into old solution cavities and increase cavity size with resulting further subsidence and groundwater contamination. (See 11 and 13.Q-R)

E. UNDERGOUND GAS STORAGE

1. Siting and Operational Impacts

From an environmental perspective, underground hydrocarbon storage impacts differ only slightly from standard oil and gas operations. (See 8, 9, 10 and 11) Since less brine is handled, the potential for this type of pollution is smaller. Land use losses increase because of production equipment installations such as manifold stations, compressor units and pipelines. (See 14.H)

There are currently 21 underground natural gas storage operations in New York State. The storage reservoirs vary in size from 280 to 10,800 acres including their buffer zones. (See 4.B.5 and 14.A) The average storage reservoir has approximately 40 wells. Drilling and installation of production facilities for 40 wells involves a direct land disturbance of roughly 15 to 30 acres out of the total land area held by the storage facility. (See 14.D)

New York has one mined cavern used for storage of liquified petroleum gas (LPG). The greater construction activity results in large temporary land-use impacts because of the land needed to store excavated material which is later sold or disposed of. Mined storage caverns, though relatively uncommon, may present special problems for landscape and soil resources. The large volume of mined rock excavated from the cavern may be disposed of on site where it can cause significant changes in topography. (6.H, 6.N, 14.B.3, 14.E-F)

Because of the magnitude of the land area disturbed by storage fields, they can have adverse impacts on the landscape. (See 14.D, 14.H, 14.J.2) In addition, storage fields may remain in operation indefinitely, making consideration of their long term impacts on landscape and soil resources especially important. These potentially adverse impacts will vary considerably depending upon the proposed location of the storage field. For example, long and short term impacts from siting a storage facility in a heavily populated area would differ greatly from use of a location encompassing prime agricultural lands or an unpopulated forest area. (See

6.I-J, 8.F) A detailed environmental review of proposed facilities is required by both New York State and the Federal Energy Regulatory Commission. As a result of these reviews, changes in the facility siting and adoption of specific mitigation measures can be required to minimize negative impacts. (See 14.C, 14.H and Appendix 1)

Erosion and other localized impacts on landscape and soils are generally minimal because of strict State and Federal controls on storage field construction, operation and abandonment. (See 6.H, 6.N, 8.H, 14.C-D, 14.H, 14.J.2 and Appendix 1) Potential impacts on soil resources from accidental spills are also low because large quantities of pollutants (oil, brine, etc.) are not stored on site.

2. Surface and Groundwater Impacts

Impacts on ground and surface waters from gas storage wells are similar to those for other gas wells except that there is less brine production associated with gas storage wells. (See 6.B-C, 8.E, 8.F.4, 8.G-H, 9.F.3, 9.H.6-7, 10.B.1.a, 10.B.2.a, 11.A, 11.E.1 and 11.H)

If the excavated rock from a mined storage cavern is disposed of on site, water leaching down through the debris may carry high sediment loads which could negatively impact adjacent surface waters. (See 14.F.1)

3. Socio-Economic Impacts

Major impacts from underground hydrocarbon storage operations are associated with social-economic issues. A landowner's mineral rights for a storage horizon can be condemned by eminent domain if a lease agreement is not reached between the landowner and operator. However, the operator must prove to the State of New York that the storage is in the public interest. (See 14.C)

A positive impact, associated with this operation, is the availability of a secure reliable energy supply during peak demand periods and/or crisis situations. (See 14.C and 18.B.6)

F. CONCLUSION

It is evident that impacts associated with mineral resource recovery are many and diverse. Some impacts are potentially significant while others are not.

It is important to recognize that adverse impacts can be mitigated. For example, the impacts on surface waters or flora and fauna may be the direct result of land use. Therefore, proper management of the land would serve to reduce the potential for associated impacts. Additionally, impacts associated with an operation in a archeologically sensitive area or Agriculture District will differ greatly from those in a wooded area, wetland, or flood plain.

Current regulations alone do not adequately mitigate the potential adverse impacts to the environment. Revision of current oil, gas and solution mining regulations, strict but consistent enforcement and an educated public and private sector are required for proper management of New York's mineral resources. (See 17)