Mémoire

Présenté à

La Commission du Bureau d'audiences publiques sur l'environnement (BAPE)

«Les répercussions d'un échange de terrains sur la biodiversité et l'intégrité écologique du Parc national du Mont-Orford»

Par

Pierre Dépôt
20 chemin du Lynx
Orford (QUÉBEC) J1X 6V7
Courriel: lacbowker@cooptel.qc.ca
Site Web: www.lacbowker.ca.tc

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INTRODUCTION

Le parc du Mont-Orford est un héritage collectif légué par ceux qui en ont été les initiateurs dans les années 1930, des gens de la région qui ont contribué à la réalisation du rêve de M. George Austin Bowen. Sa création n'origine donc pas du gouvernement du Québec, qui s'en est porté acquéreur par la suite. Cet héritage lui a été légué sur la base d'un lien de confiance que ce territoire demeurerait protégé à perpétuité. D'ailleurs la loi fondatrice du parc national du Mont-Orford, datée du 8 avril 1938, ne permettait pas de soustraire des terrains au parc, mais uniquement d'en ajouter. Bien que la Loi des Parcs en vigueur comporte des articles 4 et 5 apparemment contradictoires, elle n'en conserve pas moins le même esprit de la protection permanente du territoire à l'article 1.

L'intégrité territoriale et écologique du parc national du Mont-Orford n'est donc pas négociable. Les pressions supplémentaires qu'imposerait un plus grand achalandage du parc à l'avenir requièrent le respect intégral du concept de l'Écotourisme. D'ailleurs, l'ex-ministre responsable des Parcs, Richard Legendre, dans son allocution au Sommet Mondial de l'Écotourisme à Québec le 19 mai 2002, a mis énormément d'emphase sur la mission de conservation des parcs. Il affirmait, et je le cite : ***«À l'instar des autres réseaux de parcs nationaux dans le monde, la mission des parcs québécois consiste, d'une part, à assurer la conservation d'éléments représentatifs ou exceptionnels du patrimoine naturel et, d'autre part, à favoriser leur mise en valeur par l'offre d'expériences de découverte respectueuses de ce patrimoine.»***

À propos de sa politique sur les parcs, l'ex-ministre était éloquent : «***La primauté de la conservation y est clairement établie et s'impose dans le respect du principe de l'impact minimal acceptable sur le patrimoine»***.

Dans cette optique, comment accepter que le hall d'entrée de ce patrimoine collectif exceptionnel soit cédé à l'entreprise privé, pour y aménager un complexe immobilier qui aura l'effet d'une muraille bloquant l'accès du Parc aux Écotouristes? La primauté de la conservation devrait reléguer au second rang ces moyens douteux visant à soi-disant assurer la survie de la station de ski alpin, une activité nécessitant des installations et de lourds aménagements irrespectueux de l'Écotourisme.

Plutôt que d'échanger ou de charcuter des terrains du parc, au gré des lobbies économiques et des spéculateurs fonciers, la mission première de conservation du Parc du Mont-Orford nous prescrit un agrandissement significatif de son territoire, et de préserver nos acquis ancestraux.

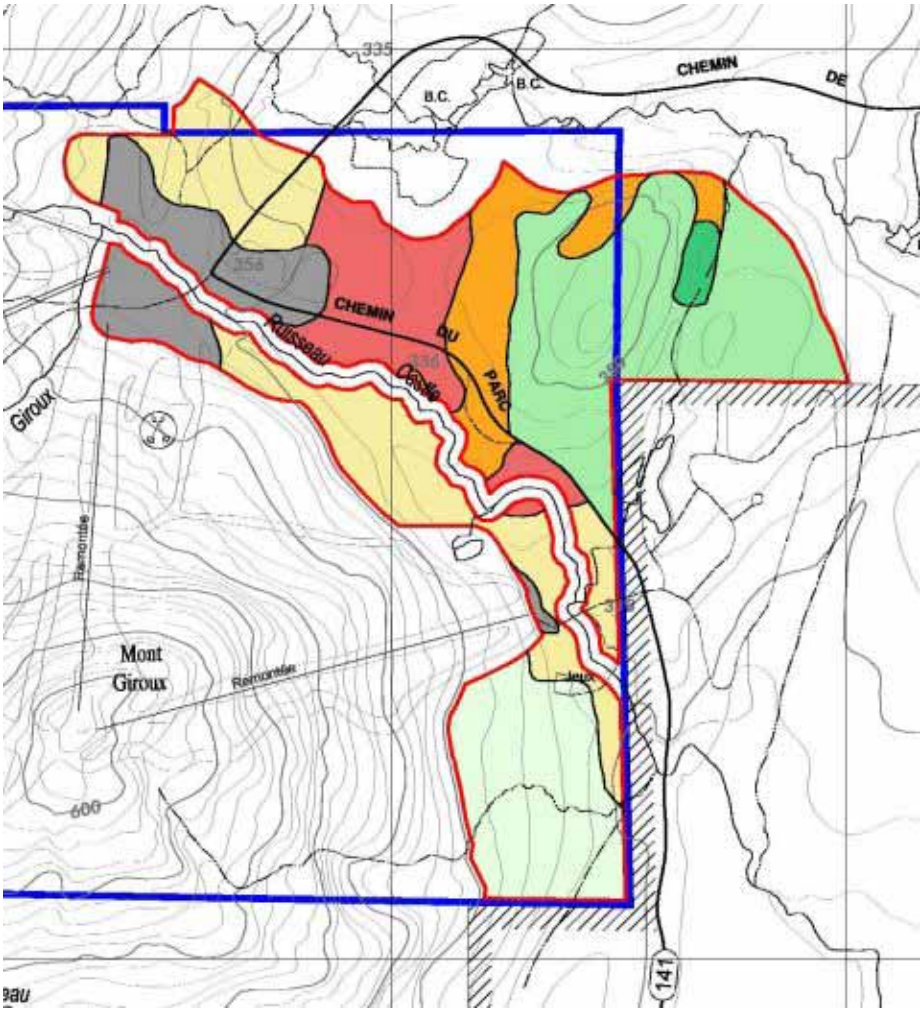
Or, il s'avère qu'ailleurs dans le monde, une nouvelle tendance se dessine en faveur de la création et de l'agrandissement des parcs ou des aires protégées. Une tendance mondiale encore pratiquement inconnue au Québec, alors que d'autres provinces canadiennes commencent à s'y intéresser. La diversité biologique rend des services indispensables à la société, sur le plan de l'équilibre écologique, de la sécurité alimentaire ou de la recherche médicale, notamment. Les forêts des bassins hydrographiques d'alimentation en eau potable fournissent un de ces loyaux services essentiel qu'offre la biodiversité, et vu sous cet angle, l'être humain est lui aussi partie intégrante de la biodiversité, lorsque celle-ci contribue à la satisfaction de ses besoins fondamentaux.

Le projet d'urbanisation et d'amputation du territoire du Parc national du Mont-Orford, à l'intérieur du bassin hydrographique du lac Memphrémagog, un réservoir d'eau potable pour plus de 150 000 personnes, va totalement à contre-courant de ce mouvement international, et ce mémoire s'emploiera à le démontrer.

1- La valeur écologique des terrains sujets à l'échange

Si on s'en tient précisément au mandat de cette commission du BAPE, il ne fait aucun doute que les terrains que le promoteur veut acquérir possèdent une valeur écologique supérieure à ceux qu'il envisage offrir en échange, bien qu'il ne possède pas encore officiellement le terrain de M. Jacques Darche, l'option d'achat étant échue depuis belle lurette.

Deux ans après la consultation de décembre 2002, portant sur la modification des limites du Parc du Mont-Orford, ce n'est que très récemment que les documents **DB4** et **DB72** ont été dévoilés, soit octobre 2004 et janvier 2005. Un dévoilement plus hâtif des ces informations aurait permit à la population de discerner, sans l'ombre d'un doute, que le terrain convoité par le promoteur est de plus grande valeur écologique, étant en majeure partie constitué d'une érablière à bouleau jaune de 50 ans, en jaune pâle, en plus d'une érablière à hêtre et frêne blanc de 90 ans, en vert pâle.



Érablières à hêtre et frêne blanc de 90 ans, en vert pâle, et à bouleau jaune de 50 ans, en jaune pâle

En comparant la carte du document **DB72** avec le photoplan de la MRC Memphrémagog, on comprend mieux les inquiétudes de M. Guy Jauron, membre du comité aviseur, qui affirmait sans détour dans son avis préliminaire, et je le cite : «***Les superficies de déboisement requises pour les stationnements m'effraient. En les superposant à des photo-plans, elles se retrouvent toutes dans des aires boisées. Cela va heurter l'opinion publique.***»

Ainsi, les allégations du promoteur, de certains élus, agents économiques et touristiques locaux, à l'effet que la majeure partie des terrains cédés ne seraient que des espaces dégradés par des activités anthropiques, ne tiennent plus la route. Désormais, il est incontournable de se rendre à l'évidence que l'aménagement des nouveaux stationnements P-1, P-2, P-3, P-4 et P-5, entraînera une coupe à blanc dans l'érablière à bouleau jaune de 50 ans et dans la prucheraie à érable rouge. Ce déboisement excessif sera partiellement effectué dans l'érablière à bouleau jaune de 70 ans, pour faire place à la zone résidentielle R-2.

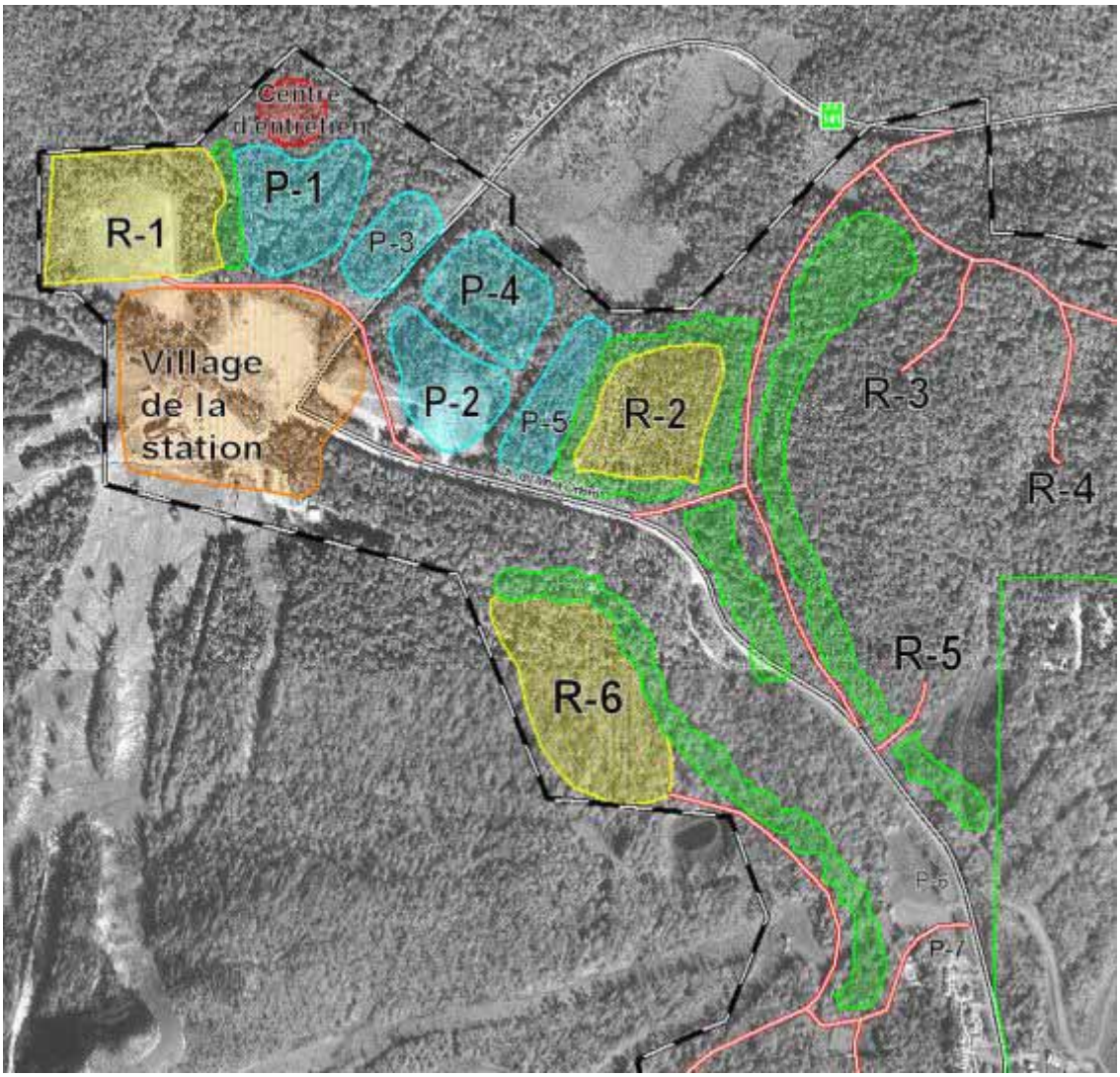
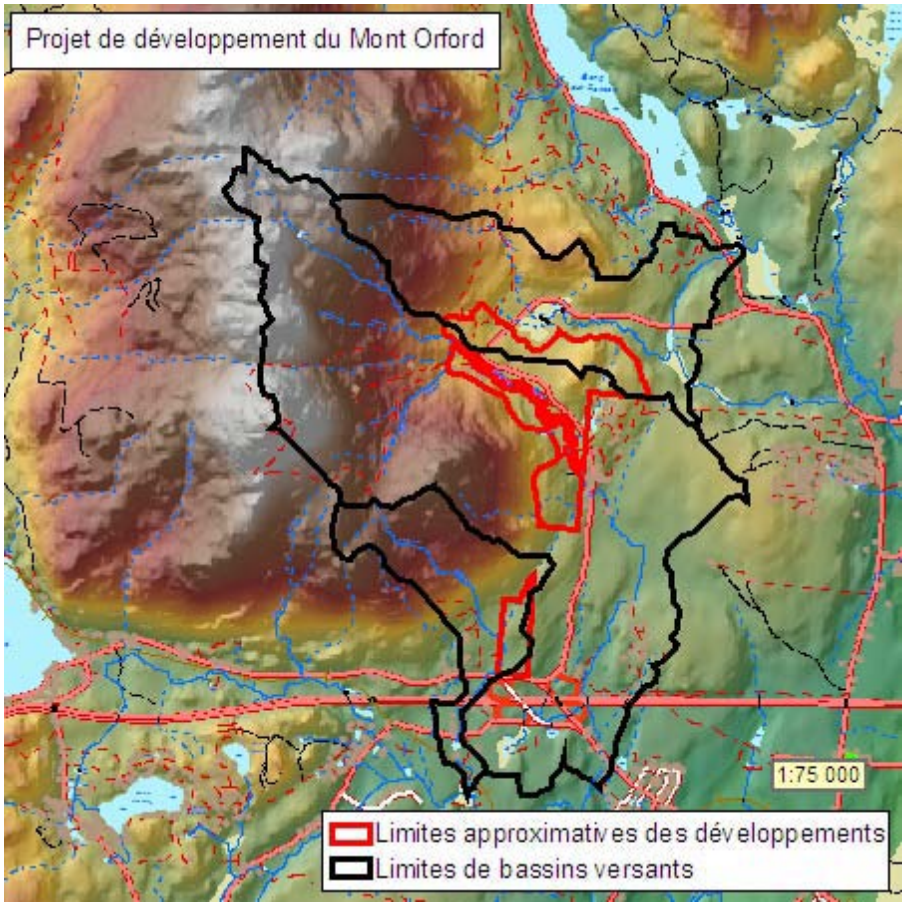


Photo plan de la MRC Memphrémagog, les affectations numérotées sont de Pierre Dépôt

La relocalisation de la route 141 entraînera une coupe à blanc d'au moins 60 pieds de largeur, en partie dans l'érablière à bouleau jaune de 70 ans, mais aussi dans l'érablière à hêtre et frêne blanc de 90 ans. Et c'est sans parler du déboisement provoqué dans le même secteur par l'urbanisation des zones résidentielles R-3, R-4 et R-5 (non indiquées par la MRC). Il est regrettable que ni le promoteur ou la MRC Memphrémagog ne soient en mesure de nous fournir les autres photoplans, afin d'obtenir un portrait aérien de l'ensemble du projet immobilier. La population n'a pas encore accès à toute

l'information, ce qui contrevient à l'engagement du Premier Ministre Jean Charest. Le document **DB4** fait mention du terrain de forme rectangulaire situé à l'extrême sud du Parc, près de la route 112. Ce terrain recèle d'un écosystème possiblement non représenté ailleurs dans le Parc, et «***présente un grand intérêt de conservations, d'autant plus qu'il est situé en bordure du ruisseau Sinueux***». De colosses pins blancs, érables à sucre, épinettes rouges, pruches et bouleaux jaunes, de 60 cm à plus d'un mètre de diamètre, y ont édifié une solide forteresse afin de protéger le Parc des envahisseurs.

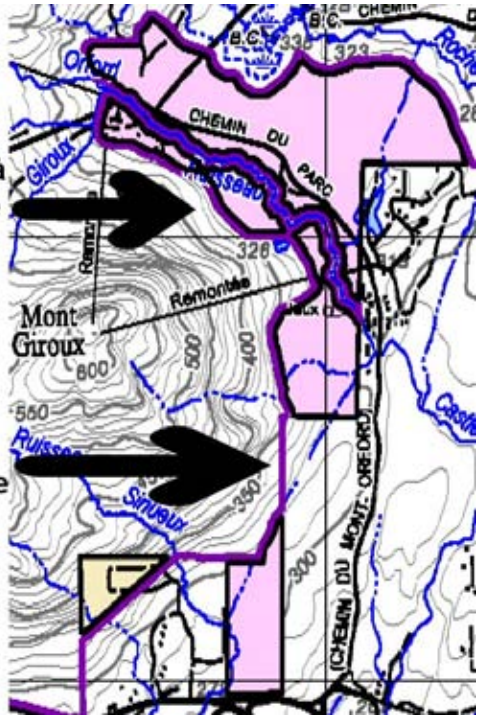


Carte du document DB66, soit les bassins des ruisseaux Sinueux, Castle et du Grand Rocher, situés en reliefs montagneux vulnérables à l'érosion.

2- La valeur marchande du terrain à la base du Mont-Orford

Selon le document de recommandation du Ministère des Transports (**DB7**), la valeur marchande des terrains cédés par la FAPAQ est de **6 500 $ l'hectare**. Or, tous sont maintenant d'avis (incluant le ministère responsable des Parcs) que cette évaluation vieille de deux ans est périmée. Non seulement les 5 terrains évalués n'étaient pas comparables, puisque très éloignés des pentes de ski, mais une transaction plus récente illustre une situation pour le moins contradictoire. Effectivement, le contrat signé par le promoteur (document **DC8**), portant sur l'achat d'une partie du territoire hors du parc qu'il veut développer, est révélateur en ce sens. Le terrain acquis le 1er novembre 2002, situé dans l'ancien Canton de Magog, et jouxtant la limite Sud du parc, est d'une superficie est de 39,8 hectares. À partir de son prix de vente de 400 000$, cela démontre que ce terrain a été payé **10 046$ l'hectare** par le même promoteur! C'est la preuve irréfutable que le terrain adjacent qu'il désire acquérir du parc est nettement sous-évalué à 6500$ l'hectare. En fait, plus on se rapproche des pistes de ski et de la base du Mont-Orford, plus la valeur marchande devrait augmenter, et non pas l'inverse!

Le document de Recommandation du Ministère des Transports est très contestable, et son indépendance fait défaut, ce qui démontre clairement que l'échange de terrains est d'autant plus inacceptable. Non seulement le parc national du Mont-Orford ne doit pas être démembré, sous aucune considération économique, ses pièces détachées n'ont pas à être vendues à rabais pour le seul bénéfice d'un promoteur immobilier.

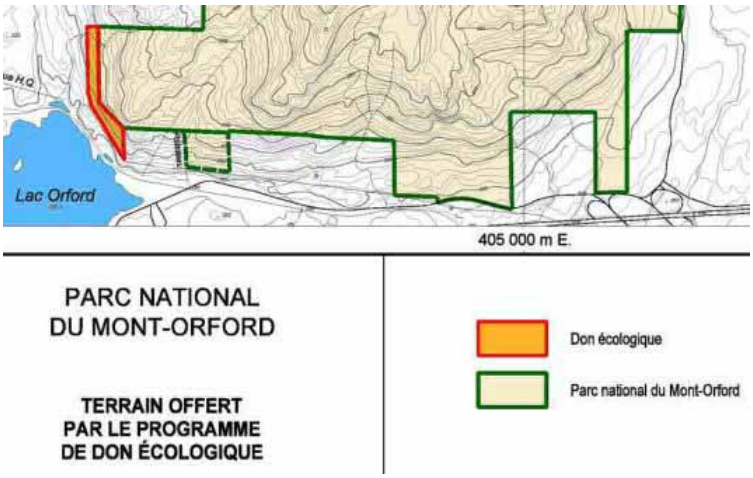


Par ailleurs, le promoteur refuse de se limiter à développer les terrains à l'extérieur du Parc, prétextant que ce sont les terrains dans le Parc, au pied des pentes de ski, qui ont un potentiel commercial intéressant. Ce raisonnement prouve implicitement que l'évaluation des terrains dans le Parc devrait être plus élevée que l'évaluation des terrains en périphérie, excluant par le fait même les terrains périphériques comme comparables valables.

En ce qui concerne les obligations financières du promoteur (réinvestissement d'une part des profits des activités immobilières dans la montagne), prévues dans l'acte de cession, il importe de nuancer qu'il ne s'agit pas d'une perte mais plutôt d'un investissement dans les infrastructures de ski, dont le promoteur sera le premier bénéficiaire, par l'augmentation de l'achalandage de la station. À long terme, ce retour sur l'investissement aura vraisemblablement l'effet de compenser les obligations financières, si bien que le processus d'évaluation n'a pas à tenir compte de ce critère avancé par le promoteur.

Il n'en demeure pas moins que ce processus compensatoire est tout de même profondément inéquitable, car ce sont le promoteur et les skieurs alpins qui profiteront de ces investissements, alors que la société en général, principalement constituée d'adeptes d'activités Écotouristiques (ski de fond, raquette, randonnée pédestre) aura été amputée d'une partie du territoire du Parc du Mont-Orford, sans que ces infrastructures de ski alpin leur soient d'une quelconque utilité.

L'évaluation des terrains aurait dû suivre le processus beaucoup plus impartial établis par Environnement Canada, relativement aux Programme des Dons Écologiques. Le document **DC26**, sur les lignes directrices relatives aux évaluations, démontre que le gouvernement fédéral a exigé le recours à un évaluateur agréé indépendant, non pas un agent d'évaluation immobilière, mais bien un membre de l'Ordre des Évaluateurs Agréés du Québec (OEAQ), avant d'annexer un terrain au Parc, dans le secteur du lac Orford.



Don Écologique de 140 000 $, 8,9 hectares, gracieuseté de M. Jacques Saint-Pierre

Ce terrain d'une superficie de 8,9 hectares a été évalué à 140 000$ (voir document **DC18-1**), ce qui représente 15730 $ l'hectare. Un terrain en pente accentuée et difficilement constructible, situé à très grande distance des pistes de ski et des remontées mécaniques. Bien que son potentiel commercial soit limité, le gouvernement fédéral, par l'entremise d'Environnement Canada, a exigé du gouvernement du Québec que ce terrain ne fasse pas le jeu des spéculateurs fonciers et demeure dans le parc ***à perpétuité***. Le document **DC25**, ***Guide du programme des dons écologiques du Canada 2003***, est sans équivoque et martèle en ce sens que les Dons Écologiques doivent être protégés à perpétuité.

Dans le même ordre d'idées, nous pouvons assurément présumer que les premiers donateurs et vendeurs de terrains au Parc du Mont-Orford, dans les années 1930, avaient les mêmes intentions que M. Jacques Saint-Pierre, et qu'ils désiraient que ces terrains puissent bénéficier aux générations futures, enjoignant ainsi le gouvernement du Québec à honorer ce lien de confiance que les fondateurs du Parc investissaient en lui.

L'exigence du gouvernement fédéral s'harmonise parfaitement avec la Loi sur les Parcs nationaux du Canada, qui ne permettrait pas l'échange de terrains envisagé au Parc ***national*** du Mont-Orford, s'il avait été un réel parc ***national***.

Selon quelle logique devrions-nous accepter que des parties du Parc puissent être échangées et d'autres pas?

Conséquemment, il faudrait faire appel à Environnement Canada dans les prochaines phases d'agrandissement du Parc ***national*** du Mont-Orford, car il faut reconnaître que le gouvernement fédéral protège mieux notre patrimoine collectif et ancestral que le gouvernement du Québec.

Poignée de main symbolique entre M. Pierre Dépelteau, Directeur du Parc du Mont-Orford, et M. Jacques Saint-Pierre, assurant ainsi la protection de son terrain à perpétuité.

À noter qu'il y a un lien direct entre la question de l'évaluation marchande des terrains et le mandat de la présente commission du BAPE. Comment des propriétaires terriens pourraient se montrer intéressés à céder des terrains au Parc, si le gouvernement du Québec les vends par la suite à rabais à des promoteurs immobiliers? De plus, si des terrains devant éventuellement servir à agrandir le Parc ne sont pas évalués à leur juste valeur, selon un processus impartial, et que leurs propriétaires ne sont pas assurés que leurs terrains jouiront d'une protection à perpétuité, le gouvernement du Québec perdra ainsi la confiance des donateurs potentiels, ce qui compromettra les chances d'agrandir le Parc afin d'englober les zones tampons périphériques essentielles à la migration des espèces animales et même végétales, qui ne peuvent vivre de manière isolée sur le seul territoire du Parc. Le Parc a besoin de passes migratoires dans ce corridor naturel que constitue la chaîne des Appalaches. Le passage suivant de l'avis de Mme Francine Hone (**DB21-1**) est révélateur : «***Le parc national du Mont-Orford n'atteint pas présentement ce seuil critique de 10 000 ha (100 km^2) (la superficie actuelle du parc étant de : 5 837 ha (58,37 km^2)) soit la superficie non fragmentée requise pour représenter adéquatement et maintenir la dynamique des écosystèmes des Appalaches.***»

Il faut donc comptabiliser ces inconvénients reliés à la mauvaise évaluation marchande des terrains sujets à l'échange proposé, car ils peuvent avoir des répercussions sur la biodiversité et l'intégrité écologique du trop petit Parc national du Mont-Orford.

3- La qualité de l'eau potable du lac Memphrémagog dépend de la couverture forestière du Parc du Mont-Orford

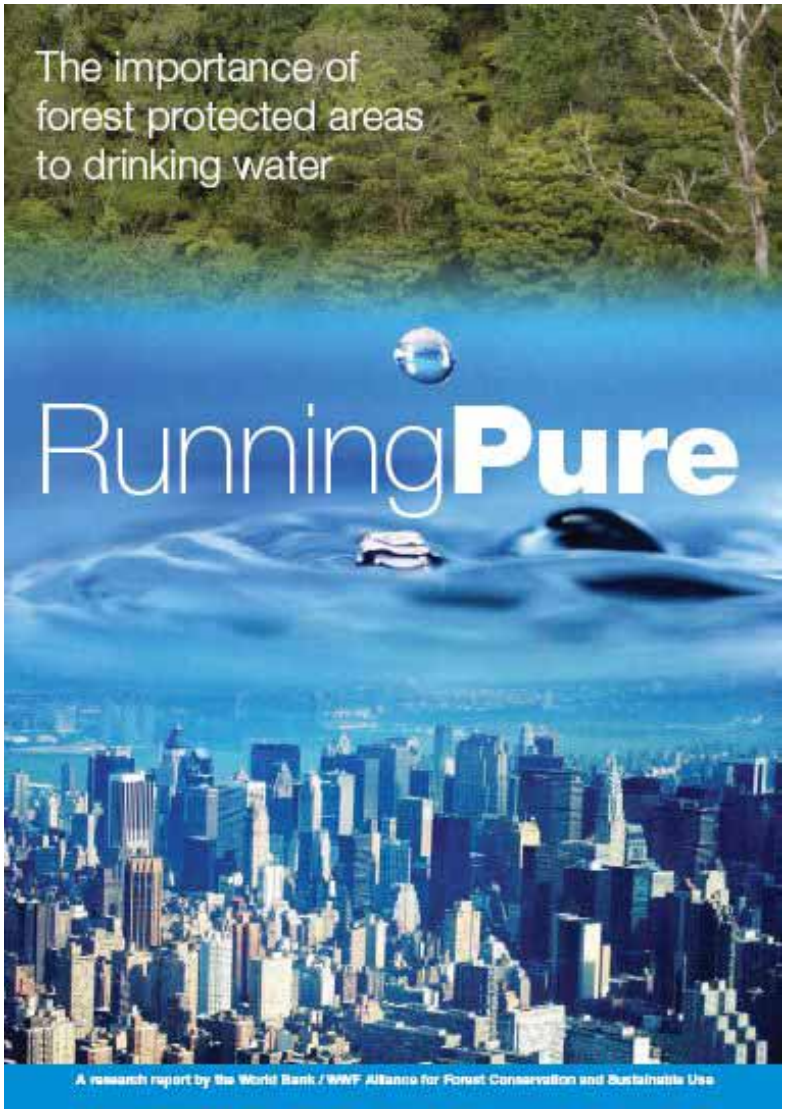
Le parc du Mont-Orford abrite sur son territoire les rares forêts protégées à l'intérieur des bassins hydrographiques de trois lacs réservoirs d'eau potable. Le lac Bowker alimente environ 4000 personnes, sur le réseau des municipalités de Valcourt, Canton de Valcourt, Lawrenceville, et Bonsecours. Le lac Orford approvisionne la ville d'Eastman, et le Memphrémagog abreuve plus de 150 000 personnes dans les Cantons-de-l'Est, principalement les villes de Magog et de Sherbrooke.

Par sa Politique nationale de l'eau, en page 46, le gouvernement du Québec s'est engagé à:

18. Préparer, d'ici 2004, une stratégie de protection des sources de captage d'eau de surface.

Le gouvernement s'engage à prendre des mesures pour protéger les sources d'alimentation en eau potable du Québec en s'inspirant des gestes posés par les États-Unis, l'Ontario, la Nouvelle-Écosse et le Nouveau-Brunswick à ce sujet.

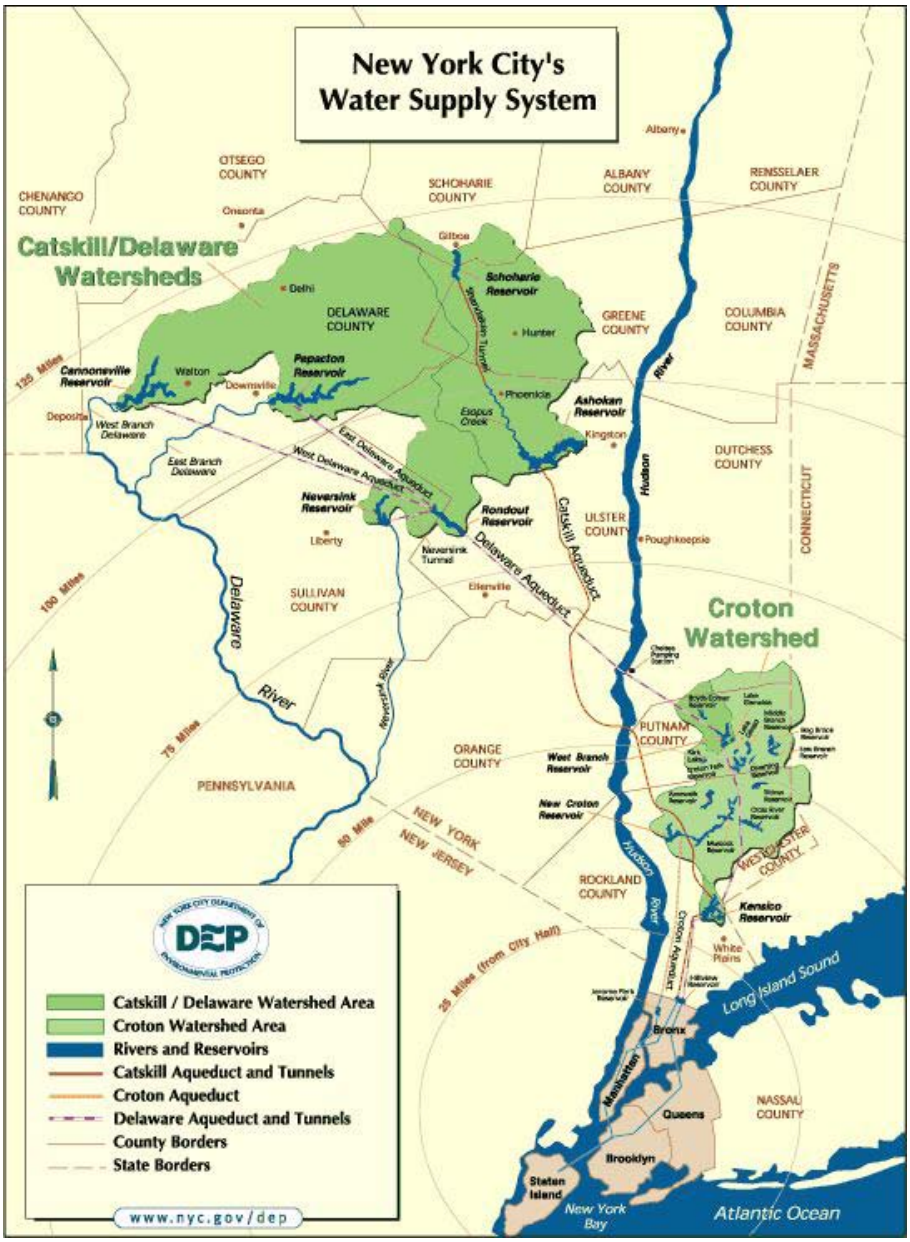
Complément nécessaire au Règlement sur la qualité de l'eau potable, cet engagement permettra de réduire les risques de contamination des eaux de surface servant de sources d'approvisionnement. Il permettra d'établir la vulnérabilité des zones de captage des eaux et de définir les actions prioritaires en vue d'améliorer la protection de la qualité de l'eau brute.



Or, le Québec tarde à honorer cet engagement, qui lui permettrait de s'élever à la hauteur de ce qui se fait ailleurs sur la planète. La Banque Mondiale, en collaboration avec le WWF (Fond Mondial pour la Nature) et l'IUCN (Union internationale pour la conservation de la nature), a publié en 2003 un rapport démontrant qu'il serait temps de poser des gestes concrets en faveur de la protection des forêts, qui sont vitales pour la qualité de l'eau potable des grandes villes du monde.

Intitulée ***Running Pure – The importance of forest protected areas to drinking water***, cette étude exhaustive révèle que 33 des 105 villes étudiées, parmi lesquelles New York, Jakarta, Tokyo, Bombay, Rio de Janeiro, Los Angeles, Barcelone, Nairobi et Melbourne, tirent leur eau potable d'endroits où les forêts sont totalement ou partiellement protégées (voir les pages 30 à 32 du rapport pour la liste complète et le statut de protection selon les catégories d'aires protégées de l'IUCN).

Ainsi, protéger les forêts s'avère bien meilleur marché que de construire des usines de filtration. Le cas de la ville de New York, dont il a été question en première partie de ces audiences du BAPE, nous indique qu'il en coûte sept fois moins cher que si elle avait dû se munir d'installations de filtrage. Plus précisément, la protection des forêts des deux bassins hydrographiques, d'une superficie totale de plus 5000 kilomètres carrés, a permit d'économiser 9 milliards U.S, et des coûts d'opération de 350 millions par années.



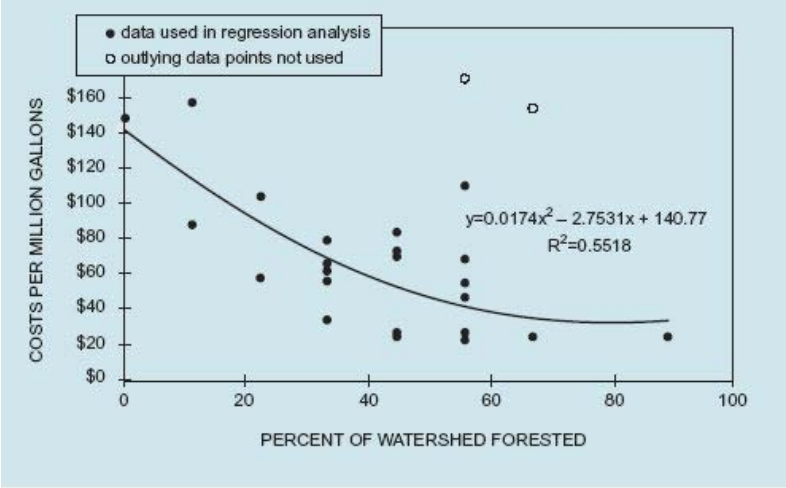
Dans le débat économique entourant le projet immobilier au Parc du Mont-Orford, il serait pertinent de mettre dans la balance les économies générées par la protection des terrains boisés filtrants à l'intérieur du Parc du Mont-Orford, un service public de filtration, que les Sherbrookois et Magogois sous-estiment grandement.

Plus encore, le document Running Pure nous apprend que les propriétés filtrantes des forêts sont littéralement à l'origine de la création de Parcs et d'aires protégées officielles à travers le monde, reconnues selon l'une ou l'autre des six catégories de l'IUCN! C'est notamment le cas d'une partie des bassins new-yorkais, c'est-à-dire le bassin Catskill/Delaware, empiété par le Catskill State Park de catégorie 5.

Traditionnellement, les gens évitaient de se construire en zone montagneuse. Les montagnes épargnées sont ainsi devenues des endroits propices à l'alimentation en eau potable de qualité, d'autant plus que leur altitude favorise le captage de l'eau des nuages, un aspect quantitatif non négligeable. Le rapport Running Pure est éloquent en ce sens: «***28 per cent of the world's forest areas are in mountains, and mountains are the source of some 60 to 80 per cent of the world's freshwater resources***».

M. David Cassels, expert environnemental à la Banque Mondiale, affirme que «***Préserver les zones de captage pour assurer l'approvisionnement des villes en eau potable montre à l'envi qu'investir pour la santé de l'environnement profite autant aux êtres humains qu'à la nature***». «***Pour de nombreuses agglomérations, protéger les forêts dans les zones de captage n'est plus un luxe mais une nécessité. Car sans ces forêts, la fourniture en eau potable deviendra très chère***.»

Le document ***PROTECTING THE SOURCE, Land Conservation and the Future of America's Drinking Water,*** du TPL (Trust For Public Land www.tpl.org), abonde dans le même sens en page 21.



Une étude du TPL , en collaboration avec l'American Water Works Association, en 2002, auprès de 27 fournisseurs d'eau potable aux États-Unis, indique que plus le couvert forestier est grand, moins les coûts de filtration sont élevés.

Selon l'étude, approximativement 50 à 55% de la variation des coûts de traitement peut être expliquée par le pourcentage de couvert forestier dans le bassin hydrographique de la source d'eau potable. Ainsi, pour chaque augmentation de 10% du couvert forestier dans le secteur de la source, les coûts de la filtration et autres traitements chimiques ***diminuent*** d'environ 20%, et ce jusqu'à 60% de couvert forestier.

Au-delà d'un couvert forestier de 65%, soit de 70 à 100%, les coûts de ces traitements deviennent pratiquement nuls.

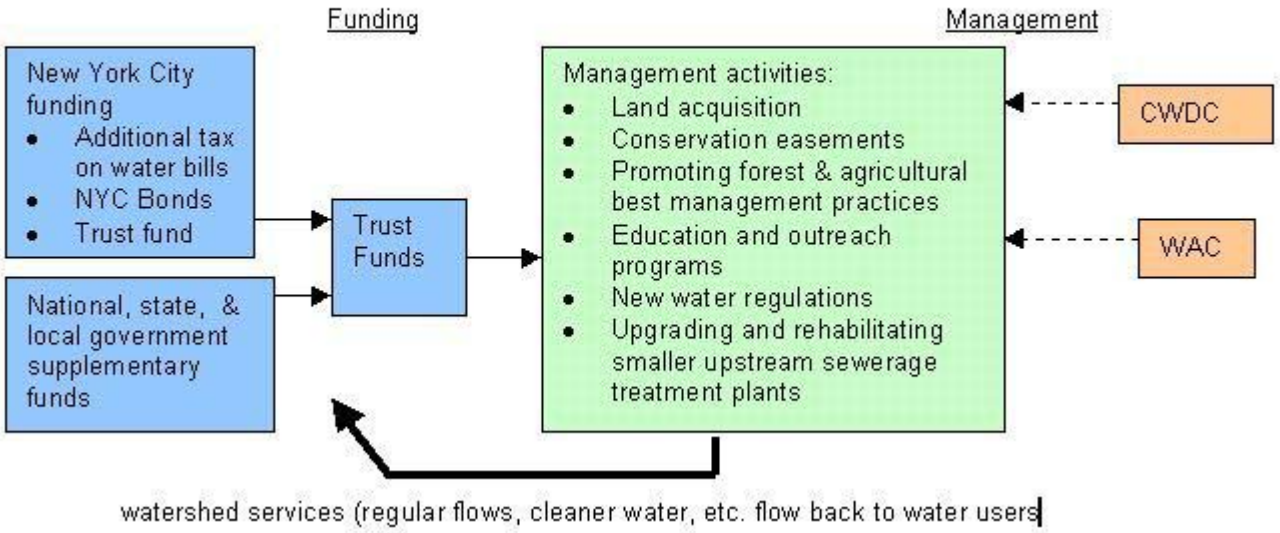
C'est la raison pour laquelle la protection des sources d'eau potable est devenue un puissant incitatif afin de favoriser la création d'aires protégées à travers le monde, avec des mécanismes de redevances élaborés pour épargner au maximum les terrains boisés, et de les soustraire au développement immobilier.

C'est aussi la raison pour laquelle il faut agrandir le Parc du Mont-Orford à l'intérieur des bassins hydrographiques des lacs Bowker, Orford et Memphrémagog, et forcément se prémunir contre toute tentative de retrait de terrains boisés déjà protégés. Pour financer l'achat des terrains, il faut s'inspirer de ce qui est déjà en place pour la ville de New York mais également de partout à travers le monde. Dans la majorité des cas, le mécanisme de redevance est très simple, car il utilise la taxe d'eau existante pour financer l'acquisition des terrains boisés.

Des localités de la Floride imposent une taxe d'eau de 3% à des fins similaires. Des localités des États de Washington et du Rhode Island imposent une taxe d'eau de 15$ par année dans le premier cas et d'un cent par 100 gallons dans le second, spécifiquement dédiée à la protection des sources d'eau et à l'achat de terrains boisés.

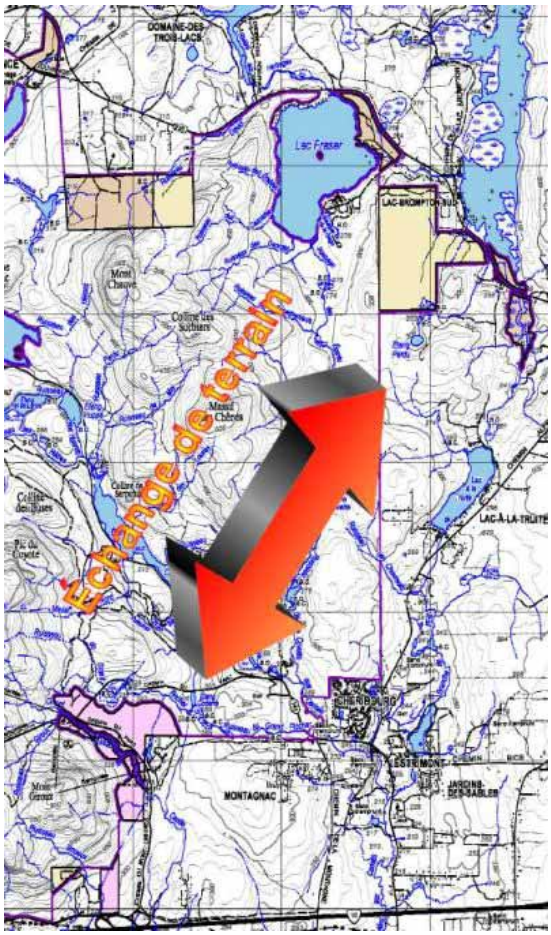
Ainsi, un pourcentage de la taxe d'eau des Sherbrookois et Magogois devrait servir à financer l'agrandissement du Parc du Mont-Orford dans le bassin hydrographique du lac Memphrémagog. Les citoyens des municipalités qui s'abreuvent à partir l'aqueduc de Valcourt pourraient eux aussi être mis à contribution, pour agrandir le Parc dans le bassin hydrographique du lac Bowker.

Figure 3: The water-based finance mechanism of New York City



Les contribuables accepteront volontiers de payer un peu plus pour la taxe d'eau, puisqu'elle génèrera des économies à long terme, et ***SI*** on leur donne l'assurance que les sommes perçues serviront exclusivement à des fins de conservation. On peut ainsi lire ce qui suit en page 3 du document ***Payments for Watershed Services***, ***Conservation Finance Alliance***, de Washington D.C. http://guide.conservationfinance.org/chapter/index.cfm?Page=3 :

«*Other roles that the government can potentially play are to collect user fees or taxes, and to contract with upper-watershed inhabitants to implement conservation measures. In the case of a public payment scheme (see section 1.3.2) where government has mandated an additional water-use fee for the purposes of watershed protection,* ***it should ensure that funds raised are targeted towards the watershed project rather than be counted as general revenue.***»



Vu sous l'angle de cette perspective plus globale, l'échange de terrains proposé est d'autant plus inacceptable, car l'amputation du parc dans le bassin hydrographique du lac Memphrémagog sera compensée par l'ajout d'un terrain situé dans le bassin hydrographique du lac Brompton, qui n'est pas reconnu comme étant un réservoir d'eau potable, n'étant pas raccordé à un aqueduc municipal.

Les 150 000 personnes qui s'abreuvent à même le lac Memphrémagog y perdront au change. Puisque l'alimentation en eau potable est un besoin fondamental, nous pouvons certes conclure que 150 000 êtres vivants dépendent en permanence et sont partie intégrante de la biodiversité du secteur du Parc du Mont-Orford menacé par un échange de terrains et un développement immobilier. Cette question est par conséquent directement reliée au mandat de la présente Commission du BAPE.

Concernant la bande de protection de 25 mètres le long du ruisseau Castle, c'est nettement insuffisant. Parmi les provinces canadiennes qui protègent leurs bassins hydrographiques où sont situées des prises d'eau de surface, on compte la Nouvelle-Écosse, le Nouveau-Brunswick, Terre-Neuve, et partiellement la Colombie-Britannique, pour les trois bassins qui alimentent les villes de Vancouver et Victoria. Dans ce derniers cas, ces bassins ne sont pas habités ni accessibles au grand public. Les bassins des provinces maritimes sont quand à eux habités, et bien qu'ils soient qualifiés de *Protected Areas*, ils ne sont pas officiellement classés comme étant des aires protégées selon les 6 catégories de l'IUCN. Mais vu l'intérêt de la Banque Mondiale et le WWF pour ce type de protection de forêts habitées, il ne serait pas surprenant que l'IUCN établisse une septième catégorie d'aires protégées éventuellement. Déjà en Europe, on recense environ 500 désignations différentes de forêts protégées, incluant celles qui servent à l'alimentation en eau potable d'agglomérations urbaines, et reconnues comme des aires protégées selon la Convention de Ramsar sur les zones humides, (http://www.ramsar.org/indexfr.htm).

Le Nouveau-Brunswick est désormais reconnu comme étant le chef de file au Canada dans ce domaine des «*aires protégées habitées*» :
http://www.ledevoir.com/2002/09/19/9389.html
http://www.gnb.ca/cnb/newsf/elg/2001f1078el.htm

Les 30 bassins hydrographiques désignés approvisionnent en eau potable environ 300 000 personnes réparties dans 21 municipalités et touchent globalement 4 % du territoire de la province. Les bassins hydrographiques néo-brunswickois sont divisés en trois zones. La zone A comprend tous les cours d'eau du bassin versant; la zone tampon B est une bande de terrain de **75 mètres** en bordure de ces cours d'eau; enfin, la zone C définit la superficie de terrain restante du bassin versant.

Dans la zone B, le développement domiciliaire est stoppé avec l'objectif de conserver le maximum de végétation pour filtrer le ruissellement et éviter une augmentation du nombre d'installations septiques. Les nouveaux projets de développement industriel et commercial sont aussi arrêtés. Pas de nouveaux aménagements touristiques destructeurs, comme les terrains de golf ou de camping, aucune nouvelle exploitation agricole, etc. (Voir la carte délimitant les trois périmètres de protection du lac Chamcook, à la page suivante)

En comparaison, le projet de développement projeté au Parc du Mont-Orford ne cadre pas avec les efforts des autres juridictions de ce monde en faveur de la protection des sources d'eau potable. Non seulement l'usine de filtration naturelle que constitue le Parc du Mont-Orford n'a pas à être démembrée, mais cette ultramince bande de protection de 25 mètres pour le ruisseau Castle est inacceptable, puisque nos voisins néo-brunswickois en exigeraient 75 mètres sur toute la longueur du ruisseau, incluant les secteurs en dehors du Parc!

SCHEDULE A-29
ANNEXE A-29

PROTECTED AREAS - CHAMCOOK LAKE WATERSHED - TOWN OF SAINT ANDREWS

SECTEURS PROTÉGÉS - BASSIN HYDROGRAPHIQUE DU LAC CHAMCOOK - TOWN OF SAINT ANDREWS

Town of Saint Andrews, N.B.

Town of Saint Andrews (N.-B.)

Legend / Légende

Protected Area A
Secteur protégé A

Boundary of a Protected Area B
(Protected Area B does not include any Protected Area A)
Limites d'un secteur protégé B
(Le secteur protégé B n'englobe aucun secteur protégé A)

Boundary of a Protected Area C
(Protected Area C does not include any Protected Area A or Protected Area B)
Limites d'un secteur protégé C
(Le secteur protégé C n'englobe aucun secteur protégé A ou secteur protégé B)

Water Intake
Prise d'eau

Crown Reserved Road
Chemin réservé de la Couronne

Plan:	A-29
Scale: / Échelle :	1 / 15 000
Date:	2001 / 07 / 13

Department of the Environment and Local Government
Ministère de l'Environnement et des Gouvernements locaux

New Nouveau Brunswick

NOTES:

1 The property lines shown on this plan were transferred from Service New Brunswick property maps. The property lines are shown on this plan to aid in the identification of individual properties within the watershed protected areas. Please refer to the actual Service New Brunswick property maps for complete property and ownership information.

2 A copy of the *Watershed Protected Area Designation Order* that designates the watersheds or portions of watersheds shown on this plan as protected areas

(a) is filed in the head office of the Department of the Environment and Local Government, and in the regional office of the Department of the Environment and Local Government situated most closely to the protected areas, and

(b) is registered in the registry office or registry offices of Service New Brunswick for the county or counties in which the protected areas are situated.

NOTES :

1 Les limites de propriétés figurant sur le présent plan ont été décalquées des cartes foncières de Services Nouveau-Brunswick. Elles y figurent pour faciliter l'identification des propriétés particulières se trouvant à l'intérieur des secteurs protégés du bassin hydrographique. Veuillez vous reporter aux véritables cartes foncières de Services Nouveau-Brunswick pour obtenir des renseignements complets à l'égard des propriétés et des propriétaires.

2 Un exemplaire du *Décret de désignation du secteur protégé des bassins hydrographiques* qui désigne les bassins hydrographiques ou des parties des bassins hydrographiques figurant sur ce plan comme secteurs protégés

a) est déposé au bureau principal du ministère de l'Environnement et des Gouvernements locaux, et au bureau régional du ministère de l'Environnement et des Gouvernements locaux qui est le plus rapproché des secteurs protégés, et

b) est enregistré au bureau de l'enregistrement ou aux bureaux de l'enregistrement de Services Nouveau-Brunswick du comté ou des comtés où sont situés les secteurs protégés.

PLAN: A-29

CONCLUSION

Le mandat de cette Commission du BAPE ne porte pas sur la recherche de compromis ou de moyens financiers visant à assurer la survie de la station de ski alpin du Mont-Orford. Bien que ce mémoire se limite à une analyse approfondie de seulement trois aspects, ils sont tous en lien direct avec le mandat de cette commission.

Il est déplorable que le ministère responsable des Parcs n'ait livré aussi peu d'informations à la population depuis les deux dernières années. Le dévoilement récent de documents sur le site web du BAPE aura eu le mérite de démontrer que l'échange de terrains proposé nuirait à l'intégrité écologique du Parc. Mais l'échange porterait aussi atteinte à la biodiversité représentée par des forêts matures et intactes, des forêts uniques possiblement non représentées ailleurs dans le Parc, qui disparaîtraient en bonne partie par l'aménagement des stationnements et par le développement immobilier sur le terrain rectangulaire près de la route 112.

Ce mémoire a aussi abordé des questions économiques, non pas relatives à la création d'emplois, ce qui aurait été en dehors du mandat de cette commission, mais en rapport direct avec celui-ci, soit les économies générées par les forêts du Parc du Mont-Orford, qui font office de membranes filtrantes pour les 150 000 personnes qui s'alimentent en eau potable à partir du lac Memphrémagog. Avant de conclure sur cette lancée, il serait opportun de définir ce qu'est la biodiversité selon l'IUCN:

«***" La diversité biologique, ou biodiversité, est la variété et la variabilité de tous les organismes vivants. Ceci inclut la variabilité génétique à l'intérieur des espèces et de leurs populations, la variabilité des espèces et de leurs formes de vie, la diversité des complexes d'espèces associées et de leurs interactions, et celle des processus écologiques qu'ils influencent ou dont ils sont les acteurs [dite diversité écosystémique]".***

(XVIIIè Assemblée Générale de l'IUCN, "the World Conservation Union", Costa Rica,1988).»

Ainsi, quand des forêts protégées à l'intérieur d'un Parc contribuent à la satisfaction d'un besoin aussi fondamental que l'alimentation en eau potable, l'espèce humaine fait en quelque sorte partie de la biodiversité dont elle dépend pour sa survie.

L'évaluation marchande des terrains est aussi un aspect économique important, si on veut maintenir le lien de confiance avec des propriétaires terriens, dans l'objectif d'agrandir le Parc, dont l'intégrité écologique et l'équilibre des processus naturels propre au maintien de la biodiversité nécessitent un agrandissement de sa superficie.

L'échange de terrains est donc inadmissible, car à l'exemple d'une course à relais, on doit s'assurer que les terrains acquis au Parc du Mont-Orford demeureront protégés à perpétuité, par respect non seulement des fondateurs du Parc, qui nous ont légué cet héritage d'une valeur inestimable, mais aussi des générations à venir, à qui il faut le transmettre à son état originel.

Que le rêve de George Austin Bowen se poursuive jusque dans la nuit des temps…

À cet égard, afin de protéger la santé publique, le gouvernement s'engage à :

17. Soutenir financièrement, au cours des cinq prochaines années, la mise aux normes de toutes les installations d'approvisionnement et de traitement de l'eau potable.

Cet engagement vise à soutenir les municipalités dans la modernisation des installations d'approvisionnement et de traitement de l'eau potable, afin de respecter le *Règlement sur la qualité de l'eau potable*. Le gouvernement investira les sommes nécessaires, dans le cadre des programmes d'aide existants, afin de soutenir les municipalités dans la réalisation de travaux de mise aux normes de leurs installations.

Cette modernisation aura des retombées économiques, techniques, scientifiques et sociales importantes. Dans la mise en œuvre de cet engagement, l'on tient compte du renforcement de l'expertise et du savoir-faire québécois en matière de technologie de traitement de l'eau potable.

18. Préparer, d'ici 2004, une stratégie de protection des sources de captage d'eau de surface.

Le gouvernement s'engage à prendre des mesures pour protéger les sources d'alimentation en eau potable du Québec en s'inspirant des gestes posés par les États-Unis, l'Ontario, la Nouvelle-Écosse et le Nouveau-Brunswick à ce sujet.

Complément nécessaire au *Règlement sur la qualité de l'eau potable*, cet engagement permettra de réduire les risques de contamination des eaux de surface servant de sources d'approvisionnement. Il permettra d'établir la vulnérabilité des zones de captage des eaux et de définir les actions prioritaires en vue d'améliorer la protection de la qualité de l'eau brute.

19. Augmenter et améliorer la capacité d'intervention, d'enquête, d'évaluation des risques ou des impacts des directions régionales de santé publique, lors d'éventuels dépassements de normes de la qualité de l'eau ou lors de l'éclosion de maladies d'origine hydrique.

Le gouvernement mettra en place des systèmes de surveillance continue et efficace des maladies d'origine hydrique. L'Institut national de santé publique du Québec réalisera les études scientifiques nécessaires et contribuera à la formation spécialisée concernant l'eau. Ces actions visent l'amélioration de la capacité du gouvernement à protéger la santé de la population et à prévenir les problèmes de santé publique causés par l'eau. Un meilleur accès à l'information sur les maladies et sur les contaminations est un des éléments clés permettant l'atteinte de cet engagement.

5.2 PROTÉGER LES ÉCOSYSTÈMES AQUATIQUES

Les écosystèmes aquatiques et riverains ainsi que les milieux humides tels que les marais, marécages et tourbières sont reconnus pour leur richesse écologique, leur biodiversité ou encore pour leur fonction d'épuration. Par ailleurs, ils font aussi l'objet de multiples formes d'exploitation économique et d'activités récréotouristiques (pêche, chasse, piégeage, aquiculture, ornithologie, activités nautiques, extraction de la tourbe). Cependant, le développement des activités humaines engendre parfois des impacts négatifs sur ces milieux. Certaines activités liées aux pratiques d'aménagement en milieu forestier, à l'aménagement de structures pour protéger les rives contre l'érosion, à l'empiétement et au dragage ou à la modification du profil des cours d'eau pour améliorer le drainage agricole ou urbain sont des exemples d'activités qui font subir des pressions importantes aux écosystèmes aquatiques. À cet effet, des pratiques destinées à diminuer les impacts de certaines de ces activités ont été développées au cours des années. C'est ainsi que la méthode du tiers inférieur (enlèvement des sédiments et végétaux dans la portion inférieure du fossé) appliquée aux travaux d'entretien permet de diminuer l'érosion dans les fossés agricoles, forestiers ou routiers et à limiter l'apport de sédiments au cours d'eau principal.

The importance of forest protected areas to drinking water

Running**Pure**

A research report by the World Bank / WWF Alliance for Forest Conservation and Sustainable Use

Running Pure: The importance of forest protected areas to drinking water

A research report for the World Bank / WWF Alliance for Forest Conservation and Sustainable Use

Written and edited by Nigel Dudley and Sue Stolton

With major research and contributions by Rachel Asante Owusu, Ahmet Birsel, David Cassells, José Courrau, Lawrence Hamilton, Sedat Kalem, Wang Luan Keng, Leonardo Lacerda, Yıldıray Lise, Stefano Pagiola, Sara Scherr and Claudio Sericchio

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Preface

Three years ago, WWF and IUCN's World Commission on Protected Areas organised a conference on management effectiveness of protected areas in Bangkok. One of its major conclusions was that, if protected areas are to be maintained in the long term, their essential roles and broader services, beyond biodiversity conservation, need to be emphasised. Many governments are finding it increasingly difficult to justify the maintenance of protected areas, if the wider benefits for local communities and the society at large cannot be demonstrated.

This report represents an early attempt to develop wider arguments for protection, focusing on one narrow but important issue – the potential role of protected areas in helping to maintain water supply to major cities.

It is a good time to look at the links between water and protected areas. The United Nations has proclaimed 2003 as the *International Year of Freshwater*, to help promote new and existing water resource initiatives. IUCN's *World Parks Congress (WPC)* in September 2003 provides a once-in-a-decade global focus on protected areas and their importance. The role, definitions, boundaries and management of protected areas are receiving particular attention from governments and non-governmental organisations, corporate bodies and development agencies. Two key issues have been prominent in the discussions leading up to the WPC: the need to stress the arguments for protected areas away from a narrow focus on biodiversity into other values (the congress is named *Benefits beyond Boundaries*) and the importance of securing enough resources to manage protected areas effectively. The links between protected areas and drinking water thus touches some of the most central natural resource management issues in the world today.

Water, as we shall show, provides a powerful argument for protection. Through payment for environmental services it can also help to defray the costs of managing protected areas if, as is increasingly the case, governments introduce charges for pure water coming from forests protected by the state.

Dr Claude Martin
Director General
WWF International

Contents

Executive summary

Well managed natural forests provide benefits to urban populations in terms of high quality drinking water:

- Well managed natural forests almost always provide higher quality water, with less sediment and fewer pollutants, than water from other catchments
- Some natural forests (particularly tropical montane cloud forests and some older forests) also increase total water flow, although in other cases this is not true and under young forests and some exotic plantations net water flow can decrease
- Impacts of forests on security of supply or mitigating flooding are less certain although forests can reduce floods at a local headwater scale
- As a result of these various benefits, natural forests are being protected to maintain high quality water supplies to cities
- Protection within watersheds also provides benefits in terms of biodiversity conservation, recreational, social and economic values
- However, care is needed to ensure that the rural populations living in watersheds are not disadvantaged in the process of protection or management for water quality

Maintaining high quality water supply is an additional argument for protection:

- Many important national parks and reserves also have value in protecting watersheds that provide drinking water to towns and cities
- Sometimes this is recognised and watershed protection was a major reason for establishing the protected area – here watershed protection has sometimes bought critical time for biodiversity, by protecting natural areas around cities that would otherwise have disappeared
- In other cases, the watershed values of protected areas have remained largely unrecognised and the downstream benefits are accidental
- Where forests or other natural vegetation have benefits for both biodiversity and water supply, arguments for protection are strengthened with a wider group of stakeholders
- In some cases, full protection may not be possible and here a range of other forest management options are also available including best practice management (for example through a forest management certification system) and restoration

The watershed benefits of forest protected areas could help to pay for protection:

- The economic value of watersheds is almost always under-estimated or unrecognised
- It is possible to collect user fees from people and companies benefiting from drinking water to help pay for the catchment protection benefits provided by protected area management – although only in certain circumstances
- Payment for water services can also be one important way of helping negotiations with people living in or using watersheds to develop land-use mosaics that are conducive to maintaining high quality drinking water supplies

Many of the world's largest cities rely on drinking water from protected areas:

- Around a third (33 out of 105) of the world's largest cities obtain a significant proportion of their drinking water directly from protected areas
- At least five other cities obtain water from sources that originate in distant watersheds that also include protected areas
- In addition, at least eight more obtain water from forests that are managed in a way that gives priority to their functions in providing water
- Several other cities are currently suffering problems in water supply because of problems in watersheds, or draw water from forests that are being considered for protection because of their values to water supply

Rationale for the project

Forests and freshwater systems interact in many different ways: through soil stability and sediment load; fisheries and fish hatching; the impacts of different tree species on acidification of water; mitigation of incidence and severity of flooding from headwater catchments; management of downstream water logging and salinity; influencing the availability of water for irrigation systems; maintaining the quality of water for industrial purposes; and so on. Issues relate to the presence of forests, forest type, management systems and choices relating to afforestation and reforestation. Many of these interactions are complex and their precise nature and significance remains the subject of debate between hydrologists, natural resource economists and ecologists.

In the following report we focus on one specific interaction: the role of forests, and particularly protected forests, in maintaining quality of drinking water for large cities.

There are many reasons for this focus: many city dwellers already face a crisis of water quality, and contaminated water spreads a vast and largely unnecessary burden in terms of short and long-term health impacts including infant mortality, with knock-on effects on ability to work, industrial productivity and on already over-stretched health services. The poorest members of society, unable to afford sterilised or bottled water, suffer the greatest impacts. Similar problems affect the rural poor as well of course, and sometimes these can be even more severe. However, in a rapidly urbanising world the scale of the problem facing cities is particularly acute[1].

The issue also seems one of particular relevance to the World Bank-WWF Alliance and its targets on increasing extent and effectiveness of forest protected areas and extent of well-managed forests outside protected areas[*]. Given that both organisations also have extensive freshwater programmes, and the World Bank has a large portfolio of projects looking specifically at drinking water, linking the forest targets with water catchments is a logical next step in developing cooperation between the two institutions. In addition, the third element in the WWF *Forests for Life* programme is forest landscape restoration, an issue currently not addressed by the Alliance; one important driver for forest restoration is the need to restore functioning watersheds, so that drinking water could also provide the means for the Alliance partners to extend their work into restoration issues.

2003 has been proclaimed by the United Nations, the International Year of Freshwater, providing a platform for promoting existing activities and spearheading new initiatives in water resources at the international, regional and national levels. Currently one person in six lives without regular access to safe drinking water, and 2.4 billion people lack access to adequate sanitation. Water related diseases kill a child every eight seconds. The global focus on water is intended to accelerate implementation of the targets in the UN Millennium Development Goals, and those set by the World Summit on Sustainable Development in 2002, to: develop integrated water resources management and water efficiency plains by 2005; halve by the year 2015 the portion of people who are unable to reach or afford safe drinking water and who are without access to basic sanitation; and achieve by 2010 a significant reduction in the current rate of loss of biological diversity.

There is another specific reason to focus on forest protected areas at the moment. The occurrence of the World Parks Congress (WPC) in September 2003 provides a rare global focus on protected areas. The role, definitions, boundaries and survival of protected areas will get particular attention from governments and non-governmental organisations, corporate bodies and development agencies.

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[*] The Alliance targets are, by 2005, to have created 50 million hectares of new forest protected areas around the world, increased management effectiveness on 50 million hectares of existing protected areas and developed independent certification of good forest management on 200 million hectares of managed forest by working with governments, the private sector and civil society.

Two key issues have come to the fore in the discussions leading up to the WPC: the need to extend the arguments for protected areas away from a narrow focus on biodiversity into other values (the whole congress is named "Benefits beyond Boundaries") and the need to find sustainable funding to manage protected areas effectively. Water, as we shall show in the following report, provides a powerful argument for protection in many cases. Through payment for environmental services, it can also help to defray the considerable costs of management if, as is increasingly the case, governments and other forest owners introduce charges for pure water coming from forests protected by the state. Indeed, privately managed protection forests are also starting to emerge in some parts of the world.

There was also a desire by the research team to move away from an over-reliance on case studies to argue a particular point of view. Specific case studies relating to the link between forests and freshwater have been well documented and frequently repeated and have certainly helped create interest in the issue. But how representative were these of the situation in most countries and most cities? We wanted, as far as is possible in a brief research project, to supply some statistics about how important forests are to urban water supplies. We therefore looked at the world's top 100 cities[†] and provided an overview of how many relied on water from protected areas for some or all of their drinking water supply.

What appeared initially to be a fairly simple question became more complex in its unravelling. Finding the information proved a challenge, but also revealed many layers of complexity. What exactly constituted a forest protected area? We had assumed official protected areas, as designated by IUCN The World Conservation Union, but found many other categories of protection, some specifically aimed at watershed protection and often with their wider values only poorly understood. In some catchments (for example around Beijing), "protection" actually means integrated management, with special controls on the type of farming and other land uses rather than on protecting forests. Not all forests set aside for catchment protection also have high biodiversity values. In some areas, governments recognise the need for restoration, or have reforestation projects already underway in important catchments. It has also become clear that the role that some official protected areas play in watershed management is barely recognised by either protected area managers or water authorities.

This wider picture mirrors the development within the Alliance as well. At present, WWF is consciously attempting to integrate its work on forest protected areas, good forest management outside protected areas and forest landscape restoration into a protect-manage-restore approach at landscape level, working in priority conservation landscapes selected by an ecoregional planning process. Therefore while the main focus of the current report remains on forest protected areas, issues of management and restoration are also addressed and feature in the policy recommendations.

We are well aware that this is a preliminary study that points the way to the need for further research, rather than providing all the answers. The main report, which follows, is supplemented by three essays, written by specialists, looking at specific issues relating to hydrology, economics and social issues, in each case giving an overview but also asking some of the questions that need to be addressed when considering the use of forest protection in terms of urban water supply. The key statistics are contained in an analysis of the world's top cities and some of these examples are then examined in greater detail in a series of short assessments.

We hope that this will be the first in a series of analyses that look at wider arguments for protected areas and other forms of habitat protection.

[†] Actually the top 105 by population, divided between the Americas (25), Africa (25), Europe (25), Asia (25) and Australia (5)

Part 1: The importance of forest protected areas to drinking water

Introduction: what do city dwellers need?

In the past 100 years the world population tripled, but water use for human purposes multiplied sixfold![2]

Water is, in theory, a quintessentially renewable resource. Most of the world's surface is covered in water and over much of the world it falls, unbidden and with great regularity, from the skies. Yet, the carelessness and profligacy with which water resources have been used, the speed of human population growth and the increasing per capita demands for water together mean that provision of adequate, safe supplies of water is now a major source of concern, expense and even international tension. At the World Summit on Sustainable Development in Johannesburg in 2002, over 80 per cent of the participating decision-makers identified water as a key issue to be addressed by Heads of State from countries throughout the world[3].

Overall, the greatest human requirement for freshwater resources is for crop irrigation, particularly in places where farming takes place in arid regions and in the great rice paddy fields of Asia. Municipal water – the focus of the current study – accounts for less than a tenth of human water use[4]. But the need for clean drinking water is of critical importance to the growing proportion of the world's population that live in cities. Wherever a breakdown in water supply occurs, because of disasters like earthquakes, floods, wars or civil unrest, immediate and acute problems occur and reliance on contaminated water results in the rapid spread of diseases like cholera and infant diarrhoea.

Unfortunately, for many people there is no need for a disaster to make them dependent on unclean drinking water. Today, around half of the world's population lives in towns and cities, and of this urban population one third, an estimated one billion people, live without clean water or adequate sanitation, despite these services widely being regarded as basic prerequisites of a decent life. These one billion extreme have-nots are unevenly distributed around the world. Regionally, it has been estimated that 700 million people in urban Asia, or half the urban population, do not have adequate water supplies; nor do 150 million people in Africa, again about 50 per cent of the city dwellers; with a further 120 million people, about 30 per cent of the urban population, lacking clean water in Latin America and the Caribbean[5]. Many people die each year as a direct result. Annually, 2.2 million deaths, four per cent of all fatalities worldwide, can be attributed to inadequate supplies of clean water and sanitation[6].

These problems are likely to increase in the future as the current rapid processes of population growth and urbanisation continue. The average size of the world's 100 largest cities grew from around 0.2 million in 1800 to 6.2 million in 2000[7]. In 1900, there were estimated to be just 43 cities worldwide with a population of over half a million, by 1990 this figure had risen to around 800 cities worldwide – of which some 270 had more than one million and 14 had over 10 million[8]. These trends are likely to continue for some time. Most current estimates suggest that the world's population will grow by two billion people over the next 30 years and another billion in the following 20 years. Virtually, all of these increases will be in developing countries, the bulk of which will occur in urban areas[9]. In India, for example, World Bank forecasts are that demand for water in the urban and industrial sectors is likely to increase by 135 percent over the next 40 years[10].

In many arid countries, there is already an acute supply shortage. World water withdrawals rose six-fold over the last century. It has been estimated that humanity now uses 54 per cent of accessible runoff, a figure that could rise to 70 per cent by 2005[11]. For several countries, current reliance on non-

renewable (or only very slowly renewable) groundwater sources masks a problem that could rapidly become more acute as these are exhausted. Because of population growth, the average annual per capita availability of renewable water resources is projected to fall from 6,600 cubic metres today to 4,800 cubic metres in 2025[12]. In 1998, 28 countries experienced water stress or scarcity (defined when available water is lower than 1,000 cubic meters per person per year). By 2025, this number is predicted to rise to 56[13]. As the number of people in urban areas grows, so does the demand for water, food and for irrigation in agricultural areas close to the city adding further pressures on water resources.

The demand for water, along with increasing pressures on water from pollution, urbanisation and overexploitation of aquatic resources, is also creating a biodiversity crisis in freshwaters[14].

Although future supply problems are expected, with a few notable exceptions the current shortfall in clean water for city dwellers is seldom to do with a real lack of supply but more related to poor distribution, inadequate treatment and to some extent also poor education and a lack of understanding about the problems. For example, up to 50 per cent of the urban water in many African cities is being wasted through leakage, theft or is otherwise unaccounted for[15]. (Conversely Melbourne, after a seven year period of extreme drought, is still supplying its citizens with some of the best quality drinking water in the world[16].) Efforts are being made to address these problems. Over the past 20 years for instance more than 2.4 billion people have gained access to water supply and 600 million to sanitation[17]. The United Nations Millennium Summit in 2000 agreed to reduce halve the 1.1 billion people who do not have access to safe water by 2015, as part of its Millennium Development Goals[18].

Cities therefore face immediate problems of access to clean water and sanitation and mounting problems of supply. In recent years, increasing interest has been taken in the opportunities for maintaining urban water supplies (and perhaps even more importantly water quality) through management of natural resources. Unfortunately, the links often come into focus when something goes wrong – most commonly when resource management upstream has downstream impacts in terms of changes in water supply, increased flooding and reduced water quality. The majority of the world's population live downstream of forested watersheds and therefore are susceptible to the costs of watershed degradation[19]. At the same time, 28 per cent of the world's forest areas are in mountains, and mountains are the source of some 60 to 80 per cent of the world's freshwater resources[20]. Hence the importance of this report.

The protected areas and protected forests identified below all play a role in providing drinking water for the world's biggest cities. More often than not this water also helps feed the people, through irrigation of crops, provide electricity through hydro-electric plants, and has a recreation, aesthetic and even religious function. Of course protected areas are just one tool in a range of watershed conservation models, that can have costs of their own, but it is hoped that by highlighting their role this report will add to the growing literature extolling the benefits of long-term protection to some of the world's most important resource areas.

Options for providing water

Most of the world's drinking water comes from surface waters (rivers, lakes or artificially constructed reservoirs) or from underground aquifers; an increasing number of countries are also investing in desalination plants to extract drinking water from the oceans. All sources face costs and problems, the latter including over-exploitation and pollution.

Municipal authorities have a variety of ways of supplying drinking water, depending on where they are located, how much resources they can afford to devote to water supply and on issues relating to social and political structure and the willingness of the population to practice water conservation measures. The vast majority of cities rely on the collection and diversion of existing freshwater sources, with minor amounts, on a global scale, extracted directly from rainwater or from the seas. Key supply routes are outlined below:

- **Direct extraction from natural surface waters, including lakes, river and streams**: such sources are amongst the most straightforward in terms of supply but in many situations require considerable processing to remove contaminants. Inhabitants of the city of Paris, for example, mainly drink water extracted from the Seine while Londoners rely on the River Thames (and it is estimated that most water from the taps has already been drunk and recycled 6-7 times).

- **Direct extraction from underground aquifers**: including both those that are renewed regularly and seasonally, and those where renewal is far slower and extraction is therefore, in the short-term, non-renewable. Currently, for example, many Middle Eastern countries rely heavily on non-renewable aquifers while the city of Milan extracts water from aquifers that are refilled more regularly. Groundwater supplies about one third of the world's population; an estimated 65 per cent of public water supplies in Europe come from groundwater sources and withdrawal in the European Union rose by 35 per cent between 1970 and 1985[21].

- **Collection of water in surface reservoirs**: either near to a city or further away; in the later case transportation becomes costly. Establishment of dams and reservoirs has become enormously controversial, both in terms of loss of land and because stemming natural water flow affects people, countries further downstream and aquatic life[22]. From a water supply perspective however, such dams often result in relatively pure water that needs comparatively little treatment: ultimately purity depends on land use within the catchments. Most cities rely on some form of reservoir, near or far.

- **Desalination plants**: the world's oceans are the largest source of water, but with too high a salt content to drink. Some countries with low freshwater supplies and abundant energy sources (fossil fuel or solar) have developed desalinisation plants to provide drinking water; this is currently a major source in Saudi Arabia for example and around the world 11,000 desalination plants contribute to drinking water supplies in 120 countries[23].

- **Rainwater harvesting**: smaller scale options also exist, including working with communities to develop direct methods of rainwater harvesting through individual or community reservoirs, collecting water from roofs, temporary streams and other easily accessible sources. Direct collection of rainwater, if practised correctly, can result in high quality water with little need for further treatment, but is obviously dependent on seasonal climatic conditions and is a source likely to be particularly vulnerable to climate change. China has developed rainwater harvesting in Gansu province and it is important in north-east Thailand; interest is not confined to developing countries and for example subsidies are available to encourage construction of rainwater tanks and seepage wells in Germany[24].

- **Water recycling**: re-use of water is encouraged in many areas, although not usually for drinking; recycling and re-use can however take the pressure off piped water supplies and thus reduce overall need for water. Re-use of drainage water can be a major supply source in areas where intensive surface irrigation is currently practised and is important for instance in the eastern Nile delta of Egypt, the north China plains, the Arkansas valley in Colorado and in Australia[25].

- **Bottled supplies**: in many of the world's cities, bottled water has become increasingly popular, in part due to fashion and good marketing and in part to genuine concerns about quality of tap water. Many of those who can afford to buy bottled water in the cities of Africa and Asia choose to do so, even if they have access to piped water, because of fears of contamination. Bottled water has become increasingly popular in Europe and North America, and worldwide sales have reached $22 billion. In part this is because of concern about pollution by nitrate, with human activities having increased the load in rivers by a factor of 2-4[26], although the relative health impacts are unclear and bottled water can have a higher bacterial contamination than tap water in these areas and far higher resource and energy costs[27].

All major water supplies have a variety of problems. Some countries are facing genuine shortages although in many others the problems relate more to access and transport: about 50 developing countries, mainly in Africa, still use less than 1 per cent of their available freshwater resources[28]. Withdrawal of water from riverine transboundary sources, such as the Nile or rivers in the Middle East are creating actual or potential political tensions and are also causing many rivers to dry up far from their outlets to the sea, with a range of ecological and economic consequences. For example, there have been long term tensions between Turkey, Iraq and Syria relating to extraction from the Euphrates-Tigris basin[29] and between Afghanistan and Iran regarding access to water from the Helmand River.

Over-exploitation of groundwater resources is a major problem in many developed and developing countries – for example in the American Great Plains, China, India, Mexico and the southern states of Central Asia – resulting in water tables falling in some cases tens of metres because underground aquifers are being drawn down too quickly to be replenished. Saline intrusion into groundwater sources is a problem for many coastal cities, such as Jacksonville, Florida, Dakar in Senegal and several Chinese cities[30] and over-extraction can also lead to subsidence.

Pollution of all water sources provides major problems, both in terms of cost and health, with pollutants coming mainly from agriculture, sewage, industry and resource activities such as mining[31].

Until recently, the main focus of efforts to improve urban water sanitation and supply have focused within the cities themselves, on better distribution systems, treatment plants and sewage disposal. However, throughout the world, municipal authorities are now increasingly looking up into the hills towards the forested watersheds that supply their precious drinking water and at ways in which improvements can be made at source.

What forests can provide

*Much of the world's drinking water comes from catchments that are or would naturally be forested. There appears to be a clear link between forests and the **quality** of water coming out of a catchment, a much more sporadic link between forests and the **quantity** of water available and a variable link between forests depending on type and age and the **constancy** of flow. Forests therefore often provide the basis for integrated management of water resources, although precise effects vary from place to place and have been the subject of dispute amongst hydrologists. Knowledge of the type and age of trees, soil conditions and user needs can help determine what kind of forest management policies will be most beneficial.*

> *The loss of forest cover and conversion to other land uses can adversely affect freshwater supplies, threatening the survival of millions of people and damaging the environment*[32].
>
> UN Food and Agriculture Organization
>
> *Integrated water resources management is based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good, whose quantity and quality determine the nature of its utilization. To this end, water resources have to be protected, taking into account the functioning of aquatic ecosystems and the perenniality of the resource, in order to satisfy and reconcile needs for water in human activities*[33].
>
> "Agenda 21"

Quantity, quality and regularity

There is a widespread assumption that forests provide useful ecosystem functions in maintaining constant supplies of good quality water. Loss of forests has been blamed for everything from flooding to aridity and for catastrophic losses to water quality.

In fact, the hydrological role of forests remains the subject of a debate. The impacts of land use on water resources depend on many ecological and socio-economic factors, making generalisations difficult. Natural factors include climate, topography and soil structure, while socioeconomic factors include economic ability and awareness of the farmers, management practices, and the development of infrastructure[34]. The precise impact of forested catchments on water supply therefore varies dramatically between places and can also vary in one place depending on such factors as the age and composition of the forest.

For the present report, we have been lucky enough to have a specially–prepared analysis by Professor Lawrence Hamilton, with David Cassells of the World Bank, which goes a long way to addressing the myths on both sides and to providing an overview that will be of use to those charged with making policy about drinking water. But no-one should assume that there is consensus as yet. The following section draws both on the Hamilton essay and recently published material by FAO and others.

*There appears to be a clear link between forests and the **quality** of water coming out of a catchment, a much more sporadic link between forests and the **quantity** of water available and a variable link between forests and the **constancy** of flow.*

Quality: forests in watersheds generally result in higher quality water than alternative land uses, if only because virtually all alternatives – agriculture, industry and settlement – are likely to increase the amounts of pollutants entering headwaters and also because in some cases forests help to regulate soil erosion and hence reduce sediment load (although the extent and significance of this will vary[35]). While there are some contaminants that forests are less able to control – the parasite *Giardia* for example – which is spreading gradually throughout North America as an invasive species, in most cases presence of forests will substantially reduce the need for treatment. Where municipalities have protected forests to protect water supply, it is issues of water quality that have generally been the primary driving forces and this is the focus of much of our report.

If forests are managed other than for protection, the type of management has significant impacts on water quality. There have been many studies of the impacts of forest management on water quality[36], which have generally shown that sediment yield increases after timber harvesting[37], but also that changes in management practices can help reduce this damage[38]. Applying fertilizer without using best management practices can also result in water pollution[39] and governments have addressed the impacts of these and other forestry practices through legislation, such as the Clean Water Act in the USA[40].

Quantity: the situation with regard to the flow of water from catchments is more complex. Despite years of catchment experiments, the precise interactions between different tree species and ages, different soil types and management regimes are still poorly understood in many situations, making accurate predictions difficult. The impact of land use on runoff depends on many variables, the most important being the water regime of the plant cover in terms of evapotranspiration, the ability of the soil to hold water (infiltration capacity), and the ability of the plant cover to intercept moisture[41].

In contrast to popular understanding, many studies suggest that both in very wet and very dry forests, evaporation is likely to be greater from forests than from land covered with other sorts of vegetation, leading to a decrease in water from forested catchments as compared with, for example, grassland or crops[42], although there are important exceptions to this as outlined below. For example, a review of 94 catchment experiments concluded that the establishment of forest cover on sparsely vegetated land decreases water yield, due to higher evapotranspiration[43].

Planting new forests, particularly of species with high evapotranspiration rates, can often lead to reduced water flow. The debate about the hydrological impacts of eucalypts has continued for many years[44] and prompted a review by the Food and Agricultural Organisation of the United Nations[45], which concluded that eucalypts are likely to reduce water yield and that in the humid tropics, young eucalyptus plantations may consume more water and regulate flow less well than natural forests. A number of observations from South Africa indicate that increased dry period transpiration following forestation with pine or eucalyptus species will significantly reduce low season water flows[46]. Planting *Eucalyptus grandis* in the Mokobulaan research catchments resulted in streams drying up completely nine years after planting. When the eucalypts were clear-felled after 16 years, perennial stream flow did not return for a further five years, the long lag time being thought to be due to very deep soil moisture deficits generated by the eucalypts, which required many years of rainfall before field capacity conditions could be re-established[47]. In the Mae Thang watershed in Thailand, afforestation programmes also led to water shortages downstream, which resulted in a seasonal closure of a water treatment plant and lower availability for irrigation[48]. In Fiji, large-scale pine afforestation in watersheds previously covered by grassland led to reductions in dry-season flow of 50-60 percent, putting the operation of a hydro-electric plant and drinking water supply at risk[49]. Research in Nepal suggests that it is only several decades after tree planting that the rainfall absorption capacity of a once degraded soil starts to come anywhere near its former value under natural forest conditions[50].

Natural forests have a more complicated relationship with water flow and some appear to increase flow rates. The most significant example is cloud forest, where leaves collect water from clouds and this additional water may exceed transpiration losses. Recent work in northern Costa Rica suggests that the pattern of cloud formation above forested and cleared areas differs[51]. In addition, some very old forests also apparently increase available water, for instance research suggests that mountain ash (*Eucalyptus regnans*) of 200 years or more in Australia increases water flow[52] and depending on the species, old forests may consume less water than the vegetation that establishes itself after clear-cutting[53].

In general, the evidence seems to suggest that cloud forests and some older natural forests can increase net water flow, but that some other types of forests – including particularly young forests and plantations, are likely to have the reverse effect. Local variations may change these general tendencies.

Regularity: as important as total water is constancy of flow, both in terms of maintaining dry season flow and reducing sudden surges in water and resulting flooding during periods of heavy rain. Here opinion remains divided and examples of very different responses can be found: in some cases dry season flow is depressed by the presence of trees while in other cases it is increased. There are differences between natural forests and plantations, but again these differences do not show a constant trend. There is also little evidence that forests regulate major floods, although flooding was the reason for introducing logging bans in, for example, Thailand and parts of China. One important exception to this general rule is flooded forests, which do appear to have a role in regulating water supply, both lowland forests such as the Varzea forests on the Amazon and swamps in the uplands. Furthermore forested catchments can have important local impacts in regulating water flow, so for example are an important components in the landscape for people and communities in upland areas.

In addition, the undisturbed forest with its understory, leaf litter and organically enriched soil is the best watershed land cover for minimizing erosion by water. Any activity – such as litter collection, fire, grazing or scraping in logging – that removes this protection increases erosion. In minimizing water erosion, forests reduce the problem of sedimentation: the carrying or deposition of soil particles in water courses. Suspended soil in water supplies can render potable or irrigation water unfit for use, or greatly increase costs to make it useful.

What forests provide therefore depends to a large extent on individual conditions, species, age, soil types, climate, management regimes and needs from the catchment. Information for policy makers remains scarce and models for predicting responses in individual catchments are at best approximate.

The policy response

Towns and cities are therefore faced with a bewildering diversity of opinions on which to make hard financial and politically-charged decisions about their water supply. Not surprisingly, they have reacted in a variety of ways.

Quite a number of municipalities already cite maintenance of water supply as a reason for introducing forest protection or reforestation; for example reforestation of the Pyrenees in Spain is being promoted by the government to improve downstream water resources[54]. In a number of cases there is good evidence that forests can help maintain water flow – for example in Melbourne in Australia as discussed below (page 74) and in some cities fed by cloud forests as is the case for the Caribbean National Forest in Puerto Rico[55]; in other cases this decision is based on belief rather than hard science.

A larger number of users refer to the link between forest and water quality. In France, Perrier-Vittel, the world's largest bottler of natural mineral water, draws its most important water sources from heavily farmed watersheds where nutrient runoff and pesticides threaten the aquifers that the company

relies upon. As a response, Perrier-Vittel has found that reforesting sensitive infiltration zones, financing farmers to build modern facilities, and switching to organic farming practices are cheaper than building filtration plants[56].

Some water authorities already make the link between protecting for water and protecting for nature – the link that lies at the heart of this report and which will be discussed in more detail later. In the USA, all states are required under federal law to complete a Source Water Assessment by 2003, which promotes the idea that protecting drinking water at the source is the most effective way of preventing drinking water contamination[57] and many examples of watershed protection come from there. Around 85 per cent of San Francisco's drinking water comes from the Hetch Hetchy watershed, an area located in Yosemite National Park (Category II, 308,273 ha) that captures water inflows from the watershed in the Hetch Hetchy Reservoir and snowmelt runoff from the Tuolumne River[58]. Further up the coast in Seattle, Washington, the primary sources of water are the Cedar River watershed (36,650 ha) and the South Fork Tolt watershed (5423 ha), which together serve a population of 1.2 million people with unfiltered drinking water. To protect the endangered and threatened species in its Cedar River Watershed, while maintaining stringent water quality standards, Seattle has developed a *Habitat Conservation Plan*, which includes commitments to establish an ecological reserve on about 64 per cent of the land it owns and operates; and to develop a programme to manage the commercial harvest of timber on lands not part of the ecological reserve[59]. As part of these efforts, Seattle does not permit agricultural, industrial, and recreational activities in the watersheds, and residential use of the watersheds is prohibited[60].

The city of New York is famous for its use of protected forests to maintain its high quality water supply and is described in a later case study. But other cities in the region also rely on forested catchments. The Pine Barrens ecosystem covers some 567,000 ha, making up almost 30 per cent of the state of New Jersey. The area contains a huge aquifer in the middle of New Jersey (the Cohansey aquifer containing 17 trillion gallons of water), which supplies water to hundreds of thousands of people, living in the densely populated townships south of New York and east of Philadelphia.[61] The Pinelands National Reserve is 445,500 ha; nested within this area is 378,270 ha managed by Pinelands Commission. Among the primary motivations for its protection is the desire to protect the aquifer, which is particularly vulnerable because it lies under sandy soil in an area that is expected to undergo enormous development, and the forest also maintains an important berry industry. The area contains the Category V protected area, the Pinelands National Reserve (438,210 ha).

In Europe, many forest authorities also explicitly cite watershed functions within their plans. The Bavarian alpine forest *Plan of Forest Functions* for instance identifies and maps all forest functions, and reports that site protection involves 40 per cent of forests, protection against avalanches 22 per cent and protection of water resources 46 per cent[62].

Such activities are not confined to Europe and North America. The Mount Makiling Forest Reserve, around a hundred kilometres south of Manila in the Philippines is a 4,244 ha area of forest administered and managed by the University of the Philippines, Los Baños. It is an important resource due to its biological, watershed, recreational, geothermal, educational and other scientific values. It is also a major source of employment and economic benefit to its immediate and surrounding communities. More than 50 per cent of the reserve is forested and its watershed ecosystem supplies water to five water districts and several water cooperatives that provide water for domestic, institutional and commercial water users. Recreational areas in the reserve are maintained through user charges. In principle, these fees are expected to ration the use of resources, by reducing congestion and resource degradation[63].

While a growing number of local and national governments are turning to forested areas for their water supply, the reasons for doing so often remain in dispute. In Panama, reforestation in catchments has been promoted both to reduce sediment load into the canal and to increase overall water flow. Panama City and Colon's drinking water comes from the watershed of the Panama Canal[64]. It was estimated that if 1,000 ha/year of deforested land in the watershed was reforested, it would not be necessary to construct an additional dam proposed for the Rio Ciri[65] and on the basis of these predictions new laws were passed (with USAID support) to promote forestation of the Panama catchments as a means of enhancing flows and improving the functioning of the canal[66]. However, the science was challenged by consultants from the World Bank, who questioned whether the evidence justified using public funds to reforest pasture areas and concluded that forest cover would not necessarily improve dry season stream flow[67]. Meanwhile the role of the trees in reducing sedimentation continues to be debated and for example the Director of Watersheds and the Environment of Panama's Canal Ministry was reported as saying that his department would support massive reforestation efforts to protect the Canal's water supply[68].

Forests therefore offer a range of options for water quality, depending on their type, location, age and on what water users need. A growing number of towns and cities around the world are recognising this and working with landowners and users in catchments to maximise water benefits, although often struggling with inadequate data on likely impacts. Some of the more general management implications are examined in the following section.

Management options for watersheds

Once the potential benefits of forested watersheds are recognised, a number of different management options exist, including protection, sustainable management and, where necessary, restoration. First, decisions need to be made about the potential benefits from forests

Managers are faced with a number of critical questions: about whether forested watersheds offer real benefits; how much forest is required to gain benefits for water; and how it can best be managed. In most cases choices will not relate just to supply of water, but this priority will have to jostle for space with other demands on the land, so that management for water will have to be balanced and traded off with management for other uses. The table below outlines some questions that need to be addressed before any decisions are made about management of forests.

Issue	Details
What kind of water supply is required?	A number of questions relating to the type of water supply are important ▪ Are the pressures on water supply primarily driven by the need to get enough water, or a constant supply of water, or is the priority more to do with water quality? ▪ What quality issues are most important? (For example amount of sediment will be most important for hydropower uses whereas pollutants like agrochemicals will also be of key concern for drinking water)
How is vegetation in the catchment likely to affect water quality and flow?	This question needs specialist analysis; although some generalisations can probably be made (cloud forests are likely to increase water, some old natural forests may also increase flow, young forests and plantations are likely to decrease flow) individual cases need to be assessed in turn, depending both on conditions (soil, climate, forest types and age, management regime) and on need
What is land use?	Current status is important, but so are recent changes and likely future trends
Answering these three questions will help to determine what natural vegetation (and perhaps also other land uses) in the catchment offers in terms of water supply and whether future changes are likely to create problems or conversely whether planned changes could improve net benefits. With this information, more strategic analysis can help plan optimum management interventions.	
What other demands are there on land in the catchment?	Some questions to determine both other pressures on the land and also how much land might be available for water management ▪ Are other pressures on land likely to improve or degrade water? ▪ How much land is available, partially or completely, for water management? ▪ Can current land uses be improved from the perspective of the water from the catchment? ▪ What impacts would watershed management have for local people and what are their needs and wishes?
What are realistic management options?	An analysis of present and future management and options including: ▪ Protected areas ▪ Other forms of protective forest ▪ Managed forests ▪ Areas requiring forest restoration ▪ Other forms of land use
The analysis should tell whether the presence of forests can help the supply of water required from the catchment and provide the information needed to make informed choices about a landscape mosaic that will fulfil both water needs and other needs from the watershed.	

Different water supply options will also have impacts on freshwater and estuarine habitats, and on local people. The World Commission on Dams (2000) proposed guidelines to minimise impacts from both existing and proposed dams, such as measures to maintain fish populations in dammed rivers. For new dams the Commission recommended a 'needs assessment', and if there was not a better alternative to a dam, an 'options assessment' to identify the best way to maximise benefits and minimise impacts[69]. WWF (2003) has produced a simple guide to investing in dams[70].

Different approaches to management

Following on from an assessment of needs and options, those interested in management for water then have a portfolio of different management options to choose from, ranging from various forms of protection through different types of management to restoration in cases where forest has already degraded or disappeared. While our principle interest here is on the link between watersheds and protected areas, significant links with management and restoration are also apparent in the land uses within many catchments serving towns and cities and so these are considered briefly as well

Protection

Forests can be protected in a variety of ways: as official "protected areas" as recognised by IUCN's World Commission on Protected Areas or as various other kinds of protective forest. A recent survey by the United Nations Economic Commission for Europe and the Ministerial Conference on the Protection of Forests in Europe found over 500 designations of protection for forests in Europe alone[71]. Some wetlands supplying water to urban areas and their forest watersheds have also been designated as protected areas under the Ramsar Convention on Wetlands.

- **The IUCN Protected Area Management Categories**

IUCN – The World Conservation Union has developed a definition and a series of categories of protected areas: as outlined below[72]. The overall definition and categories are as follows:

Definition: *An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means*.

Category Ia: ***Strict nature reserve/wilderness protection area managed mainly for science or wilderness protection*** – an area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring.

Category Ib: ***Wilderness area: protected area managed mainly for wilderness protection*** – large area of unmodified or slightly modified land and/or sea, retaining its natural characteristics and influence, without permanent or significant habitation, which is protected and managed to preserve its natural condition.

Category II: ***National park: protected area managed mainly for ecosystem protection and recreation*** – natural area of land and/or sea designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.

Category III: ***Natural monument: protected area managed mainly for conservation of specific natural features*** – area containing specific natural or natural/cultural feature(s) of outstanding or unique value because of their inherent rarity, representativeness or aesthetic qualities or cultural significance.

Category IV: ***Habitat/Species Management Area: protected area managed mainly for conservation through management intervention*** – area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats to meet the requirements of specific species.

Category V: ***Protected Landscape/Seascape: protected area managed mainly for landscape/seascape conservation or recreation*** – area of land, with coast or sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, ecological and/or cultural value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the area's protection, maintenance and evolution.

Category VI: ***Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural resources*** – area containing predominantly unmodified natural systems, managed to ensure long-term protection and maintenance of biological diversity, while also providing a sustainable flow of natural products and services to meet community needs

Such protected areas are generally but not invariably owned by the state and have often been designated for reasons other than their environmental services: frequently because of their wildlife or biodiversity values or because they have particular scenic or cultural importance. Nevertheless, because many protected areas have been established in mountainous and forested areas, many also have watershed values and a few – such as Bukit Timah reserve in Singapore – were established specifically because of their value for water or with this being a major contributory factor. Other protected areas, such as the famous Yosemite in California, were designated because of their scenic beauty but also have important watershed values which have increasingly been recognised.

- **Protective forests**

In addition to officially protected areas, which may or may not have a function in watershed management, many governments, local authorities and even private landowners protect a proportion of their forests specifically to maintain water supplies. (Forests are also protected for other purposes, including for example avalanche control.) In some countries such "protective forests" have been long recognised and are subject to special laws regarding their protection while in other cases designation is more local and ad hoc. Forests protected for watershed values fall into a number of main categories:

- Major parts of watersheds – as described in several case studies in the current report

- Forests on steep slopes or other places where erosion is likely – the Grain for Green programme in China is aimed specifically at preventing sedimentation and soil loss from steep slopes

- Forests and woodland along stream and river banks to maintain water quality and temperature – for example as outlined in the British Columbia Forest Practices Code[73]

Management

There is evidence that in some situations careful management interventions do little harm to forests' hydrological functions and may even enhance these[74]. Forests outside formally protected areas are also often necessary for the maintenance of ecosystems services, both on individual sites and within the wider landscape. Forest management in these circumstances should therefore seek to maintain forest quality and not degrade either the timber resource or the range of associated goods and services. There have been many attempts to define what is often called "sustainable forest management", ranging from national criteria and indicators (e.g. the Montreal Process and the Ministerial Conference on the Protection of Forests in Europe) to site approaches such as independent certification of good management, for example through the Forest Stewardship Council.

Some management interventions may also be justified on occasion to maintain forests even when these are in a relatively natural state – for example the use of controlled burns to avoid a hotter and more destructive fire. More commonly, management intervention is not necessarily the best option from the perspective of water management but is the best possible compromise in crowded landscapes. In many countries demand for land is so great that total protection can and should only ever be applied to a small fraction of forests. The human population around Beijing for example is so dense that complete protection of forests is impossible, or would cause considerable human suffering, so that an integrated approach to management is taken instead. Management might include some form of timber removal or extraction of non-timber forest products such as berries, medicinal plants or fodder.

Management for water resources is included specifically within the remit of several of the National Forests in the USA. Concern to maintain the quality and quantity of water supplies has led to the establishment of management programmes for entire river basins, such as the Murray Darling Basin in Australia where reforestation is a key element in reducing the threat from salinity to Adelaide's water quality and the now classic Tennessee Valley Authority programme, started in 1933[75]. Until recently, most of the research effort has been concentrated on mitigation of problems resulting from forestry operations rather than looking at potential positive benefits from forest management and there is clearly a need for further research on this issue. In Stockholm, Sweden, the water management company has undergone Forest Stewardship Council certification of its forests to ensure that management is of the highest standards for water.

Restoration

From 1990 to 2000 the UN Food and Agriculture Organisation estimated that forests were lost at a net rate of 9.4 million ha/year, with actual deforestation reaching 16 million ha/year. In addition, the quality of much of the remaining forest is declining rapidly. The need for restoration is therefore of growing importance, including for ecosystem services. However, the role and process of restoration is not necessarily simple in these cases: poorly planned restoration or restoration using unsuitable species can result in a net loss of water flow for many years.

Forest Landscape Restoration is defined as: "*a planned process that aims to regain ecological integrity and enhance human wellbeing in deforested or degraded forest landscapes*". It focuses on re-establishing functions and key ecosystem processes across a whole landscape rather than at just planting or restoring individual sites. As such, Forest Landscape Restoration looks at a mosaic of land uses including agricultural lands and forest types ranging from plantations to natural forests. It might for example be used to help buffer a small and isolated protected area by re-establishing trees on surrounding land that, whilst having a range of social or commercial functions, could also help support native biodiversity. The key principles of Forest Landscape Restoration are that it:

- Is implemented at a landscape scale rather than a site
- Has both a socio-economic and ecological dimension
- Implies addressing the root causes of degradation and poor forest quality (such as perverse incentives and inequitable land tenure)
- Opts for a package of solutions, which may include practical techniques – such as agroforestry, enrichment planting and natural regenerations at a landscape scale – but also embraces policy analysis, training and research
- Involves a range of stakeholders in planning and decision-making to achieve a solution that is acceptable and therefore sustainable
- Involves identifying and negotiating trade-offs

Examples of virtually all these types of land use can already be seen around the world, specifically linked to maintaining water supplies. The table overleaf gives some examples.

Table 1: Management options in watersheds

Type of management		Category	Example relating to drinking water
Protection	Protected areas containing forests	I (a) – Strict nature reserve	**Ecuador**: About 80 per cent of Quito's 1.5 million population have drinking water from two protected areas; *Antisana* (120,000 ha) and *Cayambe-Coca Ecological Reserve* (403,103 ha). To control threats to the reserves, the government is working with a local NGO to design management plans, which will highlight actions to protect the watersheds including stricter enforcement of protection to the upper watersheds and measures to improve or protect hydrological functions, protect waterholes, prevent erosion and stabilise banks and slopes[76].
		I (b) – Wilderness area	**Dominican Republic**: The Madre de las Aguas Conservation Area, consists of five separate protected areas including two wilderness areas: *Juan B. Pérez Rancier (Valle Nuevo) National Park* (Category Ia, 40,900 ha), and *Ebano Verde Scientific Reserve* (Category Ia, 2,310 ha). The area shelters the headwaters of 17 rivers that provide energy, irrigation and drinking water for over 50 per cent of the population[77].
		II – National park	**Honduras**: The cloud forests *of La Tigra National Park* (23,871 ha) in Honduras provide more than 40 per cent of the annual water supply to the 850,000 people of the capital city, Tegucigalpa[78], and this was a major incentive for their protection.
		III – Natural monument	No example found
		IV – Habitat/species management area	**Singapore**: *Bukit Timah and the Central Catchment Area* (Category IV, 2,796 ha) in Singapore were originally protected specifically to maintain water supply and the central catchment was also restored[79]
		V – Protected landscape or seascape	**Japan**: *Nikko National Park* (Category V, 140,698 ha) and *Chichibu-Tama National Park (Titibu-Tama) National Park* (Category V, 121,600ha) are both situated north of Tokyo and help to protect the watersheds of the main water supply for the city[80] and also provide recreational and wildlife values.
		VI – Extractive reserve	**USA**: *Angeles National Forest* (Category VI, 265,354 ha) is one of 18 national forests in the Pacific Southwest Region created specifically to safeguard and preserve water supplies[81]. These forests also supply timber and other benefits

Type of management		Category	Example relating to drinking water
	Protected forests outside protected areas	Watershed management	**Australia**: 90 per cent of Melbourne's water comes from forested catchments. Almost half are protected and much of the rest manages for water collection[82]. Other examples include Freetown, Sierra Leone and Kingston[83]
		Avalanche control	**Switzerland**: Around 8 per cent of forest is set aside as protection against avalanches: these areas are noted as regulating water flow[84].
		Game for hunting	No examples found
		Strategic reserves	No examples found
		Sacred sites	**Honduras**: Celaque mountain is called 'Box of Water' in the Lencan language and has been worshipped for millennia as a God Mountain that supplies life-giving water. Celaque mountain generates 9 major rivers, which feed clean water to nearby cities and communities[85].
		Recreational areas	**Colombia**: The Medellin River basin is the main source of water for Medellin and its source is protected in the *Alto de San Miguel Recreational Park and Wildlife Refuge* (721 ha)[86]
		Security reasons	No examples found
Management	Community benefits	Extraction from natural forest	**Malaysia**: The Rungus community in Sabah is negotiating with the government to manage forest in the Gomantong Hill for their water resources, rather than establish *Acacia mangium*[87].
		Management of secondary forests	**Dominican Republic**: When farmers in the Nizao watershed thought that deforestation reduced the duration of seasonal stream flows, they voluntarily adopted more stringent limits on tree cutting[88].
	Industrial benefits	Extensive – selective removal	**USA**: New York – one of a suite of actions supported by the water company is low impact, selective logging in the catchment to reduce impacts on water quality[89].
Restoration	Restoration of native or near-native forests	Natural regeneration	**Costa Rica**: hydroelectric utilities have funded reforestation upstream of their plants to maintain regularity of water supply. Payments re made by a power company to villagers through an NGO, with additional funds coming from the government[90].
		Assisted regeneration	**Brazil**: The forests on the *Tijuca Massif National Park*, near Rio de Janeiro, were reforested with native species to restore water supplies[91].
		Replanting with native species	**Australia**: an association of irrigation farmers are paying the State Forests of New South Wales to carry out large-scale reforestation to reduce salinity in irrigation water[92]. WWF Australia has a similar project with partners in the Liverpool Plains of New South Wales
	Industrial plantations	Exotic species	**Panama**: is intending to reforest catchment areas with plantations to reduce sediment in the Canal[93].

In practice, many water companies or authorities look at employing a suite of different responses depending on money, political and social factors and their own understanding of the likely impacts. Some of the policy implications of these changes are outlined below.

Social implications of protecting and managing forests for water supply

> *Secure and equitable access to and control of resources—and fair distribution of the costs and associated benefits and opportunities derived from conservation and development— will be the foundation of food and water security*[94]

Water catchment management offers benefits to people living downstream including millions of city dwellers who rely on water from forested watersheds. But what of the people living in the catchments themselves? Setting aside an area of land for forest protection or restoration might be good for water, but could have severe implications for the lives of people who live there and who have their own ideas about what it should be used for. For example, Mount Elgon National Park in Uganda is an important source of drinking water and water services were a major incentive for protection. But this caused conflict with local people who had used the forests for generations and abruptly found themselves excluded, creating problems that required considerable efforts to address[95]. The Manupali catchment in the Philippines provides another example of potential conflict. The catchment is an upland area surrounding the Mount Kitanglad Natural Park (Category II, 29,617 ha) in Mindanao. Property rights are insecure. In the upper watershed there are overlapping claims between the Forest Department, the ancestral communities and the migrant farm communities. The boundaries of the municipalities surrounding the protected area also overlap with the public state forests. Thus, three types of management plans must be reconciled for the land conflicts to be resolved.[96]

The main focus of this report is to investigate the links between protected areas and drinking water, but we recognise that protected areas create a potential conflict with livelihood issues. We asked Sara Scherr of Forest Trends to write an essay on the social implications of watershed protection, which starts on page 70. The following analysis draws both on this and on other experience in the area.

Land is seldom if ever freely available, so that choices about land use must be either imposed from above for the common good or negotiated with local land or right owners (or some combination of the two). In general, natural resource management is tending to move away from a reliance on imposed solutions, which have generally resulted in problems, and towards negotiated agreements and collaborative management approaches[97].

Because urban interests are more politically powerful than rural interests, watershed protection has often ignored rural people's rights, with negative impacts for millions of people, including:

- Transferring ownership or use rights to land from local people
- Denying rights of access to public or community land, forest, or water
- Offering payments for watershed services that encourage more powerful actors to appropriate land or water resources
- Establishing forest plantations on common lands valuable for livestock, wild foods and fuel
- Forcibly resettling people
- Forcing farmers to make high-cost conservation investments
- Damaging or denying access to cultural or religious sites
- Reducing employment due to closing farming, forestry or processing activities
- Diverting water to urban users

At worst, watershed protection has been a thinly disguised excuse for resettlement or social control of politically and culturally marginal groups. This has caused resentment and many programmes that established strict forest reserves or attempted to reforest farm and grazing lands have failed to achieve watershed objectives.

This has led to new approaches that seek to work with local people as watershed stewards. These recognise rights and management capacity, encourage negotiation, and provide technical and financial support for communities to invest in land management. When designed explicitly for local co-benefits, improved watershed protection may:

- Enhance the supply and quality of local water
- Restore depleted fisheries
- Increase availability of non-timber forest products
- Increase income and employment from enterprises compatible with watershed management
- Protect forest resources from invasion by outside settlers
- Reduce local health problems from contaminated water
- Validate the role of rural people as watershed stewards
- Pay local people for their role in protecting, managing or restoring watersheds
- Provide investment resources

Involving people in watershed management: in some urban watersheds, protecting or expanding forest cover will be essential for water management. Here, every effort should be made to embed biodiversity conservation and livelihood benefits into forest protection. Multiple-use community forestry can provide local income and communities and landowners can be paid to conserve resources and monitor water quality. Planting or regeneration can focus on the most critical sites for watershed services. Local people can identify sites producing unusual levels of sediment or contamination, or areas of compacted soil or barriers to water flow, that may not show up through remote sensing. They can also identify areas where there are strong community motivations to increase forest, such as around local water sources or cultural sites.

Alternatives to strict forest protection: completely undisturbed forest is not necessarily essential for good watershed management. While natural forest can often provide these functions most effectively and at a low cost, well-designed mosaics of other land uses may also do much the same. Where the "opportunity cost" of protection is very high for local people, alternatives should be explored. Timber and non-timber forest products can be produced commercially, under standards of certification. Crops may be produced using good erosion control or in agroforestry or organic systems. Rules can require wide strips of natural vegetation be left at intervals on contours on steep slopes. Financial credit, technical assistance, and marketing support can help to facilitate these changes, financed from urban water budgets or consumer charges. Critical sites for hydrological function (or biodiversity conservation) can be zoned for non-productive use, or farmers and landowners compensated for easements. Landscape mosaics that intersperse natural forest with crops, pastures or production forest can protect critical watershed sites. Upstream riparian systems can be linked to urban wetlands and larger protected areas through corridors of natural vegetation.

Strong public demand for water security can drive responses that seriously harm vulnerable populations living in and near water resources and catchment areas. However, serious attention to addressing potential social costs and impacts can result in greater net social benefits and greater sustainability of watershed and ecosystem services.

Economic benefits of protecting forests for water

One major reason why it has proved so difficult to halt and reverse global forest loss is that those who manage forests typically receive little or no compensation for the services that these forests generate for others and hence have little incentive to conserve them. Recognition of this has encouraged the development of systems in which land users are paid for the environmental services that they generate through their management. The central principles of the "payment for environmental services" (PES) approach are that those who provide environmental services should be compensated for doing so and that those who receive the services should pay for their provision. From our perspective here, this means that if particular management systems are needed in watersheds to maintain the quantity or quality of water supply downstream, the users – like drinking water or hydropower companies –should pay for these.

These benefits are known to be enormous. A team of researchers from the United States, Argentina, and the Netherlands has put an average price tag of US$33 trillion a year on fundamental ecosystem services, which are largely taken for granted because they are free. That is nearly twice the value of the global gross national product (GNP) of US$18 trillion. Water regulation and supply was estimated to be worth US$ 2.3 trillion[98]. At the national level, the economic value of the water storage function of China's forests is estimated as 7.5 trillion yuan, three times the actual value of the wood in those forests[99]. Similarly, recent studies calculated that the presence of Mount Kenya forest (Category II, 58,800ha and Biosphere Reserve, 71,759ha), alone, saved Kenya's economy more than US$20 million through protecting the catchment for two of the country's main river systems, the Tana and the Ewaso Ngiro[100]. The issue for policy makers is how to translate these values into money that can help to support particular types of land management in catchments and thus address some of the potential social issues outlined in the previous section.

PES has raised great hopes that protected areas can be supported through the environmental services that they provide, perhaps particularly water services. Although this is clearly possible, and there are some existing and successful examples of this in practice, it is also clearly no universal solution or panacea to the questions of support for protection. As this issue is at the heart of much of the thinking in this report, we commissioned an essay from World Bank Senior Environmental Economist Stefano Pagiola, which is reprinted starting on page 63: the following summary draw on his writing along with other relevant material.

Projects using water resources as a springboard for Payment for Environmental Services schemes have been most thoroughly developed in Latin America, but interest is quickening throughout the world. In Costa Rica, for example, the government has been involved in a scheme to help users such as hydropower companies to pay farmers to maintain forest cover in watersheds, while in Quito, Ecuador, water companies are helping to pay for the management of protected areas that are the source for much of the capital's drinking water.

Payment schemes only have a chance of working when conditions are right. An ideal combination would be when a relatively small amount of money used to support a particular management regime results in major economic benefits to a small group of users – like a water company. In these cases it is relatively easy to identify reasonable payments and to negotiate amongst the buyers and sellers of the environmental service. However, there are many possible complications. As discussed elsewhere, there are still disagreements about the likely impacts of management regimes and in any case these are likely to change in different places, making it sometimes hard to predict the costs and benefits of particular management approaches. Users have different needs; for example a hydropower company will be interested in quantity and freedom from sediment while a water company will have much wider quality interests. It may be difficult to identify and hence negotiate with the people using the land upstream (or

with dispersed user groups). There are risks of a few users paying for services enjoyed by many. Clumsy use of payment schemes can create perverse incentives for example by raising hopes of payment in other areas and hence blocking other ways of reforming management.

Nonetheless, such schemes are already working in several places and are receiving a high level of attention from governments and from donor agencies. For example, the World Bank is currently supporting the development or implementation of PES systems in Costa Rica, Guatemala, Venezuela, Mexico, Colombia, Nicaragua, Dominican Republic, Ecuador, El Salvador and South Africa. Many of these look specifically at the services provided by protected areas, for example project financed by the Global Environmental Facility is under preparation, focusing on Canaima National Park in Venezuela, with significant co-financing from the hydropower producer CVG-EDELCA.

Payment for environmental services is not a panacea or a universally-applicable solution to forest loss: rather it should be regarded as one of many tools in a toolbox. If used well, however, it can provide concrete support for both good forest management and forest protection.

Environmental benefits of protecting forests for water

As the following research will show, many of the world's cities rely on protected forests for some or all of their water. Some cities that are currently struggling with an uncertain water supply would be well served by protecting, managing and where necessary restoring forests in strategic places.

Such protection clearly can also have enormous benefits beyond water supply – for example for biodiversity. In places where forests are important both for biodiversity and water, the twin benefits may help develop and strengthen arguments for protection or for other beneficial management systems.

Protected areas are the cornerstones of all national and regional conservation strategies. They act as refuges for those species that cannot survive in managed landscapes and as areas where natural ecological processes can continue unhampered by human interference. They are a vital resource for continuation of natural evolution and, in many parts of the world, for future ecological restoration. Human beings benefit directly from the genetic potential contained in the world's plants and animal species, a significant proportion of which are currently at risk. Most people also believe that we have an ethical obligation to prevent extinctions caused as a result of our own actions[101].

As forests are the richest terrestrial habitats for biodiversity, forest protected areas are particularly important in many conservation strategies. While it has been comparatively easy to protect areas of remote forests, or forests with low timber value such as some boreal forests or high mountain forests, it has proven particularly difficult to agree adequate protection for rich lowland forests, particularly when these exist close to major cities. Watershed protection, by giving additional impetus to the creation of protected areas or other forms of protective forests, can play a key role in assisting biodiversity conservation strategies.

Already, some of the world's most famous protected areas – such as Yosemite in California – have an additional watershed function. In other places, forests that were initially protected mainly for water values have also proven to be of enormous value for biodiversity – particularly around cities where urban expansion often means that protected watersheds are virtually the only remaining natural vegetation – and that watershed protection is in effect buying time for biodiversity that would otherwise have disappeared. This is currently the situation in Singapore for instance. In other cities – for example Santiago in Chile, Istanbul in Turkey and Brisbane in Australia – the twin goals of pure water and biodiversity conservation are currently creating powerful cases for additional designation of protected areas. Sometimes, particularly when watershed protection is outside a formal protected area, the wider biodiversity benefits are scarcely recognised. Indeed, we have been surprised how little water companies or local authorities are reporting protection of watersheds, even in places where they take pride in their environmental record.

An example from China

Conservation organisations are starting to recognise and work with these links. The Qinling Mountains are the natural division between north and south China and are extremely biologically diverse, with important populations of giant panda, golden monkey, takin, crested ibis and clouded leopard. Qinling is also the catchment for the country's two most important rivers: the Yangtze and the Hwang He (Yellow) rivers, and is the chief water source for Xi'an, China's ancient capital, which has a population of over seven million people. A survey of the world's major watersheds carried out in 1998 highlighted serious deforestation and little protection in the watersheds of the Yangtze and Hwang He. The Yangtze watershed has lost 85 per cent of its forest and only two per cent of the watershed was protected while the Hwang He watershed had lost 78 per cent of its forests and only one per cent was protected. In 2003, the Shaanxi Provincial Government agreed to greatly expand the total protected

area in Qinling. Initially a series of panda reserves and corridors will increase protected areas by 180,000 ha from the existing 330,000 ha, with an additional proposal for seven more areas, adding approximately 225,000 ha to the protected area network. It is hoped that the reserves will also have substantial benefits for the drinking water of Xi'an and the surrounding area. The efforts to increase protected area coverage in Shaanxi Provincial Government have been celebrated by WWF as 'A Gift to the Earth' - a public celebration of a conservation action[102].

Buying time for biodiversity

In some cases, forests protected for their watershed values have only later been recognised for their biodiversity importance. Rising populations may mean that these protected watersheds become relatively less important – and examples from Singapore and Brisbane are discussed in this report – so that in these cases watershed protection has played a role in protecting habitats until their biodiversity values have been recognised.

This is not to argue that all cities should be surrounded by protected watersheds – many get their water from other sources or from protected forests that have no particular biodiversity value and are not necessarily worthy of full protected area status. But clearly where there is a coincidence of interest in forests for both their water services and their wildlife riches, opportunities for formal or informal protection are dramatically increased.

Some preliminary conclusions

The background research identified some clear issues related to watersheds and protected areas, which are summarised briefly on this page.

Natural forests provide benefits to urban populations in terms of high quality drinking water:

- Natural forests almost always provide higher quality water, with less sediment and fewer pollutants, than water from other catchment
- Some natural forests (particularly tropical montane cloud forests and some older forests) also increase total water flow, although in other cases this is not true and under young forests and some exotic plantations net water flow decreases
- Impacts of forests on security of supply or mitigating flooding are less certain although forests can reduce floods at a local scale
- As a result of these various benefits, natural forests are being protected to maintain high quality water supplies to cities
- Protection within watersheds also provides benefits in terms of biodiversity conservation, recreational, social and economic values

Maintaining high quality water supply is an additional argument for protection:

- Many important national parks and reserves also have value in protecting watersheds that provide drinking water to tons and cities
- Sometimes this is recognised and watershed protection was a major reason for establishing the protected area – here watershed protection has sometimes bought critical tie for biodiversity, by protecting natural areas around cities that would otherwise have disappeared
- In other cases, the watershed values of protected areas have remained largely unrecognised and the downstream benefits are accidental
- Where forests or other natural vegetation have benefits for both biodiversity and water supply, arguments for protection are strengthened with a wider group of stakeholders
- In some cases, full protection may not be possible and here a range of other forest management options are also available including best practice management (for example through a forest management certification system) and restoration

The watershed benefits of forest protected areas could help to pay for protection:

- The economic value of watersheds is almost always under-estimated or unrecognised
- It is possible to collect user fees from people and companies benefiting from drinking water to help pay for protected area management – although only in certain circumstances
- Payment for water services can also be one important way of helping negotiations with people living in or using watersheds to develop land-use mosaics that are conducive to drinking water

Part 2: The world's biggest cities, drinking water and protected areas

The study

To gain an idea of the importance of protected areas to water supply, we assessed how many of the world's top cities drew some or all of their drinking water from protected areas.

The methodology

The research team looked at water supply to the world's top one hundred cities – in fact 105 cities, by population, divided as follows:

- Americas – top 25
- Africa – top 25
- Asia – top 25
- Europe – top 25
- Australia – top 5

This breakdown was chosen to ensure a good geographical spread of information and to include most of the world's largest cities. The study aims to be indicative rather than definitive and using this method, cities were included from virtually every part of the world.

In each case, we looked at the water supply system and at whether protection – through official protected areas or other forms of protective forest – played a significant role in water supply. The results are summarised on two tables and then in a listing that includes details of each city by region.

Much of this work remains preliminary. We have been surprised at the variation in information about water sources: in some cities the facts are clear and also clearly understood, while in others there still remains a deal of confusion, even within those charged with maintaining water supply, about the status of land in catchments. Because few if any cities rely entirely on one source, or water from one protected area, we have had to make some relatively arbitrary choices about when protected areas become "significant" to a city's water supply. Some of the protected catchments we describe, for example in South Africa, are not predominantly forested but protection of other forms of natural vegetation also helps to preserve water quality. In the accompanying list of cities we give sources of facts and opinions and explain uncertainties.

The results

The following preliminary results

- Around a third (33 out of 105) of the world's largest cities obtain a significant proportion of their drinking water directly from protected areas

- At least five other cities obtain water from sources that originate in distant watersheds that also include protected areas

- In addition, at least eight more obtain water from forests that are managed in a way that gives priority to their functions in providing water

- Several other cities are currently suffering problems in water supply because of problems in watersheds or draw water from forests that are being considered for protection because of their values to water supply

Over the next few pages, these results are summarised in table form.

Table 2: Some cities drawing some or all of their water from protected areas

City	Protected Area
1. Mumbai (Bombay) India	Sanjay Ghandi National Park (Category II, 8,696 ha)
2. Jakarta, Indonesia	Gunung Gede Pangrango (Category II, 15,000 ha) Gunung Halimun (Category II, 40,000ha)
3. Karachi, Pakistan	Kirthar National Park (Category II, 308,733 ha) Dureji Wildlife Sanctuary (Category IV, 178,259 ha) Surjan, Sumbak, Eri and Hothiano Game Reserve (40,632ha) Mahal Kohistan Wildlife Sanctuary (70,577ha) Hub Dam Wildlife Sanctuary (27,219ha) Haleji Lake Wildlife Sanctuary (Category IV, 1,704ha
4. Tokyo, Japan	Nikko National Park (Category V, 140,698 ha) Chichibu-Tama National Park (Titibu-Tama) National Park (Category V, 121,600ha)
5. Singapore	Bukit Timah (Bukit Timah and the Central Catchment Area, Category IV, 2,796 ha),
6. New York, USA	Catskill State Park (Category V, 99,788 ha)
7. Bogotá, Colombia	Chingaza National Park (Category II, 50,374 ha)
8. Rio de Janeiro, Brazil	Within Rio de Janeiro Metropolitan area: Tijuca National Park (Category II, 3,200 ha) Tingua Biological Reserve Pedra Branca State Park Gericinó-Mendanha APA Atlantic Rainforest Biosphere Reserve and fourteen protected areas (covering a total area of 320,180 ha) also provide protection for the sources of the catchment areas supplying the city.
9. Los Angeles, USA	Angeles National Forest (Category VI, 265,354 ha)
10. Cali, Colombia	Farallones de Cali National Park (Category II, 150,000 ha)
11. Brasília, Brazil	Brasilia National Park (Category II, 28,000 ha)
12. Santo Domingo, Dominican Republic	The Madre de las Aguas (Mother of the Waters) Conservation Area: Armando Bermúdez National Park (Category II, 76,600 ha) Juan B. Pérez Rancier (Valle Nuevo) National Park (Category Ia, 40,900 ha) José del Carmen Ramírez National Park (Category II, 73,784 ha) Nalga de Maco National Park Ebano Verde Scientific Reserve (Category Ia, 2,310 ha)

City	Protected Area
13. Medellín, Colombia	Alto de San Miguel Recreational Park and Wildlife Refuge (721 ha)
14. Caracas, Venezuela	Guatopo National Park (122,464 ha, Category II) Macarao National Park (15,000 ha, Category II) Avila National Park (85,192 ha, Category II)
15. Maracaibo, Venezuela	Perijá National Park (Category II, 295,288 ha)
16. São Paulo, Brazil	Cantareira State Park (Category II, 7,900 ha) Guarapiranga Ecological Park, Morro Grande State Reserve, Itapeti Ecological Station, Juquery and Alberto Loefgren State Parks
17. Salvador, Brazil	Lago de Pedra do Cavalo Environmental Protection Area (Category V) Joanes/Ipitinga Environmental Protection Area (Category V, 60,000 ha)
18. Belo Horizonte, Brazil	Mutuca, Fechos, Rola-Moça, Taboões, Catarina, Bálsamo, Barreiro, Cercadinho, Rio Manso and Serra Azul (17,000 ha)
19. Madrid, Spain	Natural Park of Peñalara (15,000 ha) Regional Park Cuenca Alta del Manzanares (Category V, 46,323 ha)
20. Vienna, Austria	Donau-Auen National Park (Category II, 10,000 ha)
21. Barcelona, Spain	Sierra del Cadí-Moixeró (Category V, 41,342 ha) Paraje Natural de Pedraforca (Category V 1,671 ha)
22. Sofija, Bulgaria	Rila National Park (Category II, 107,924 ha) Vitosha National Park (Category IV, 26,607ha) Bistrishko Branishte Biosphere Reserve (Category Ia, 1,062 ha)
23. Ibadan, Nigeria	Olokemeji Forest Reserve (7,100 ha) Gambari Forest Reserve
24. Abidjan, Cote d'Ivoire	Banco National Park (Category II, 3,000 ha)
25. Cape Town, South Africa	Cape Peninsula National Park (29,000 ha) Hottentots Holland Nature Reserve (Category IV, 24,569 ha)
26. Nairobi, Kenya	Aberdares National Park (Category II, 76,619 ha)
27. Dar es Salaam, Tanzania, United Republic of	Udzungwa Mountain National Park (Category II, 190,000 ha) Selous ecosystem: Selous Game Reserve (Category IV, 5,000,000 ha and World Heritage site) Mikumi National Park (Category II, 323,000 ha) Kilombero Game Controlled Area (Category VI, 650,000 ha).
28. Durban, South Africa	Ukhlahlamba-Drakensberg Park, (Category I [48 per cent] and II [52 per cent], 242,813 ha, World Heritage Site, Ramsar site)
29. Harare, Zimbabwe	Robert McIlwaine Recreational Park (Category V, 55,000 ha) Lake Robertson Recreational Park (Category V, 8,100 ha)
30. Johannesburg, South Africa	Maluti/Drakensberg Transfrontier Park Ukhlahlamba-Drakensberg Park, (Category I [48 per cent] and II [51.5 per cent], 242,813 ha, World Heritage Site, Ramsar site)

City	Protected Area
31. Sydney, Australia	The Blue Mountains National Park (Category II, 247,021 ha) Kanangra-Boyd National Park (Category Ib, 65,280 ha) Dharawal Nature Reserve (Category Ia, 341 ha) Dharawal State Recreation Area (5,650 ha)
32. Melbourne, Australia	Kinglake National Park (Category II, 21,600 ha) Yarra Ranges National Park (Category II, 76,000 ha) Baw Baw National Park (Category II, 13,300 ha)
33. Perth, Australia	Yanchep National Park (Category Ia, 2,842 ha)

Table 3: Some cities where forest is managed for watershed protection

City	Forest managed for watershed protection
1. Seoul, Republic of Korea (South)	Nakdong watershed, has government established special protection zones including riparian buffer zones to restrict commercial activities around the river basins
2. Tokyo, Japan	Tokyo Metropolitan Government Bureau of Waterworks manages the forest at the source of drinking water in the upper reaches of the Tama River, to: increase capacity to recharge water resources; prevent sedimentation in the Ogochi reservoir; increase water purification capacity; and conserve the natural environment.
3. Beijing, China	Watersheds above the Miyun reservoir, the principal source of surface water for Beijing, are managed for water protection
4. Yangon (Rangoon), Myanmar	The forested watershed of the two dams, Gyobyu and Phugyi, which supply drinking water to Yangon, are managed by Forest Department of Myanmar who carry out forest conservation activities, i.e. restoration, in the watersheds.
5. Santiago, Chile	The Santiago Foothills have been classified as an 'Ecological Conservation Area', to be 'preserved in natural condition, in order to ensure and contribute to environmental balance and quality'. The forests are the source of potable water for Empresa Metropolitana de Obras Sanitarias which supplies potable water for part of the municipal district of La Reina – about 20 per cent of potable water in requirements for Santiago.
6. Stockholm, Sweden	Lake Mälaren and Lake Bornsjön, supply Stockholms water. Stockholm Vatten controls most of the 5,543 ha watershed of Lake Bornsjön, of which 2,323 ha, or about 40 per cent, is productive forestland certified by the Forest Stewardship Council. Management is focused on protecting water quality and areas are left for conservation and restoration.
7. Munich, Germany	Since the foundation of the Munich waterworks in circa 1900, forest management has been focussed on ensuring good water quality. Currently an area of 2,900 ha is managed primarily to maintain water quality and an additional area of 1,900 ha is under long-term contracts with local farmers, who commit to certified ecological/organic agriculture.
8. Minsk, Belarus	A green belt around the city of about 80 km and protective zone around the Minsk reservoir play an important role in ensuring water quality. The protective regime in these zones is quite strict, for example, logging is prohibited. Thanks to these restrictions, the forest around Minsk city has not destroyed.

City	Forest managed for watershed protection
9. Sydney, Australia	The Sydney Catchment Authority manages and protects Sydney's catchments. Around 25 per cent of the catchment is managed within 'Special Areas', which act as a buffer zone to stop nutrients and other substances that could affect the quality of water entering the water storage areas.
10. Melbourne, Australia	Ninety per cent of Melbourne's water supply comes from uninhabited forested mountainous catchments to the north and east of Melbourne. The government owned company Melbourne Water manages the water collection from these forests and has some legislative backing to protect water resources. Fifty one per cent of the water catchments are not within protected areas. Management priorities include to the protected forested catchments against the threat of bushfires.

The 105 cities by Rachel Asante Owusu, Sue Stolton and Nigel Dudley

In the chapter below we look at the world's top 105[103] cities, divided by continent, and provided an overview of how many relied on water from protected areas for some or all of their drinking water supply. Each entry gives a one line analysis of the role of protected areas or other kinds of deliberate watershed management and then a short paragraph describing water sources. Where applicable, details of protected areas are included, drawn from the *UN List of Protected Areas*[104] and from the UNEP-World Conservation Monitoring website.

- **Asia**

1. Mumbai (Bombay), India

Protected area important for city's water supply

Six lakes (Bhatsa, Upper Vaitarna, lower Vaitarna, Tansa, Vihar and Tulsi) supply Mumbai with about 663 million gallons of water a day[105]. The forested (southern tropical moist deciduous) Sanjay Ghandi National Park (Category II, 8,696 ha) is within the limits of Greater Mumbai and forms the catchments of the Powai and Vihar lakes[106].

2. Seoul, Republic of Korea (South)

Government established watershed protection zones

Lake Paldanghoho is the water source for the citizens of Seoul and its surrounding area. Seoul lies within the Nakdong watershed, one of the three watersheds (the others being the Han and Keum Rivers watersheds), which the government established special protection zones for in 1998. Protection includes the introduction of riparian buffer zones to restrict commercial activities around the river basins[107].

3. Jakarta, Indonesia

Protected areas are important for city's water supply

Jakarta's urban water supply comes mainly from the Ciliwung River and the Jatiluhur reservoir on Citarum River, located about 65 km southeast of Jakarta[108]. Two national parks Gunung Gede Pangrango (Category II, 15,000 ha) and Gunung Halimun (Category II, 40,000ha) protect watersheds which supply the city with water. Gunung Gede Pangrango National Park protects valuable examples of primary rain forest in West Java, with submontane and montane tropical rain forest covering the most extensive area[109]. The northern slopes of Gunung Gede are drained by many small streams, which flow into the Cipanas River, a tributary of the Citarum, which flows north-west to the Java sea. The north-western slopes of the park drain into the Cisarua and Cinagara, tributaries of the Ciliwung and Kali Angke Rivers which ultimately flow into Jakarta Bay and the Java Sea[110]. It has been estimated that the 60 or more rivers flowing from the park provide water worth US$1.5 billion for domestic and agricultural uses[111]. Gunung Gede forms the core of the Cibodas Biosphere Reserve. Gunung Halimun forms the principal watershed for West Java and is of considerable conservation importance as one of the most extensive areas of evergreen tropical rain forest remaining on the island. The Halimun region is one of wettest areas of Java, with a mean annual rainfall between 4000mm and 6000mm[112].

4. Delhi, India

Protected areas play no role in supplying the city with water

Most of the water comes from the Yamuna river

5. Manila, Philippines

Protected areas play no role in supplying the city with water

The Angat Dam in Norzagaray, Bulacan supplies 76 per cent of Manila Water's needs. Other sources of water are Ipo Dam (14 per cent), La Mesa Dam (7 per cent) and groundwater (3 per cent)[113].

6. Karachi, Pakistan

Protected areas are important for city's water supply

Pakistan's cities are expanding much faster than the overall population[114]. Karachi is Pakistan's largest city, is in far south of the country on the coast of the Arabian sea, between the mouths of the Indus and Hub rivers. In 1947, Karachi had a population of four million, today the population is over 14 million and is growing at an average of six per cent a year[115]. Karachi's water supply is the responsibility of Karachi Water & Sewerage Board (KWSB). At present, Karachi gets its water mainly from two sources: the Indus river and Hub reservoir[116]. The water supply from the Hub reservoir, however, has been intermittent in recent years as the dam's catchment area has remained dry in the monsoon season[117]. Forty per cent of the city's population lives in squatter settlements, and water supplies, in these and other areas is unreliable. Of the water supplied, 50 per cent is for domestic purposes, five per cent for industrial use, five per cent for commercial, and 40 per cent is lost in leakage[118]. By 1990 it was declared that nearly half the population of Pakistan enjoyed access to 'safe' water. However, researchers, noting that many diseases in Pakistan are caused by the consumption of polluted water, have questioned the classification of 'safe' used[119]. Even the 38 per cent of the overall population that receives its water through pipelines run the risk of consuming contaminated water, although the problem varies by area[120].

Kirthar National Park (Category II, 308,733 ha) and Dureji Wildlife Sanctuary (Category IV, 178,259 ha) in the province of Balochistan cover a significant part of the catchment area of River Hub and thus of the Hub reservior[121]. Kirthar lies 80km north of Karachi in the south-west of Sind Province. It covers the south-east extension of the Kirthar Range, to the west of the River Indus, and comprises a series of hill ranges, from 70m at Hub Dam to 1,004m on Karchat Mountain, separated by wide, undulating valleys. The park is part of a 447,161ha protected areas complex, being contiguous with Mahal Kohistan Wildlife Sanctuary (70,577ha) to the south, Hub Dam Wildlife Sanctuary (27,219ha) to the south-west and Surjan, Sumbak, Eri and Hothiano Game Reserve (40,632ha) to the east. Drainage from the Parks north and central sectors follows a south-westerly direction to the Indus River, whilst the west-central and south-west regions are drained by the Mahr and Hub rivers, respectively, which follow a southerly course to the sea. The parks flora is made up of communities of deciduous xerophytic trees and shrubs. Some 30 species of mammals have been recorded but larger species are either extremely rare, such as the wolf *Canis lupus* and striped hyaena *Hyaena hyaena*, or may have become locally extinct, such as leopard *Panthera pardus* and caracal *Felis caracal*. Despite their seasonality, few of the larger rivers ever dry up completely, allowing fish and other aquatic life to survive the dry season in deep pools of water. The park contains large populations of wild goat (*Capra hircus)* but is also heavily grazed by domestic stock. Full protection of core areas in the mountainous region, including cessation of grazing by domestic livestock, has enabled the habitat and its ungulate populations to recover. In 1989 the resident human population in the park was approximately 16,000, distributed among 118 permanent villages, and about 64,000ha of park land was under cultivation[122]. Are there any more recent figures on population and land ownership?

The Hub Dam Wildlife Sanctuary (Category IV, 27,219 ha) on the Hub River is 40km north of Karachi. The river rises in the Kirthar Range of eastern Baluchistan, and enters the Arabian Sea just west of Karachi. The dam is a large water storage reservoir constructed in 1981; as noted above the water level in the reservoir fluctuates widely according to rainfall in the water catchment area. The natural vegetation of the areas surrounding the dam is open forest dominated by *Olea ferruginea* and *Acacia senegal*. The area can provide a haven for water fowl and is an important staging and wintering

area for grebes, pelicans, ducks, cranes and coots. Some 48,500 waterfowl were present in January 1987, and over 53,500 in January 1988[123]. Haleji Lake Wildlife Sanctuary (Category IV, 1,704ha of lake, surrounded by a buffer zone of 5km radius) is some 75km east of Karachi. Haleji is a perennial freshwater lake, with associated marshes and adjacent brackish seepage lagoons, in a stony desert of limestone and sandstone bedrock. The lake supports abundant aquatic vegetation and a wide variety of migrant waterfowl, particularly ducks and common coot *Fulica atra*, and is particularly rich in birds of prey. Originally a saline lagoon formed by seasonal rainwater collecting in a shallow depression, the lagoon was converted into a reservoir in the late 1930s to provide an additional water supply for Karachi. The salt water was drained, embankments were constructed around the lake, and the Jam Branch Canal carrying water from Kinjhar Lake diverted to it. This canal remains the principal source of water. The main purpose of the lake is to supply Karachi with freshwater for about 15 days in the year, usually in April when the canal from Kinjhar Lake is being cleaned out[124].

Although there are clear links between the protected areas around Karachi and drinking water supplies, protection has tended to concentrate on the protection of wildlife species and habitats. Given the problems facing Karachi to supply its citizens with constant sources of freshwater however, there is scope for management to also play a role in securing waters for the city. There is also clearly need to further research into the relationship between the protected areas and water supplies.

7. Shanghai, China

Protected areas play no role in supplying the city with water

Most of the water comes from the Huangpu River, which has serious pollution problems[125].

8. Dhaka, Bangladesh

Protected areas play no role in supplying the city with water

Ninety per cent of the municipal water supply for Dhaka is derived from groundwater storage[126].

9. Tokyo, Japan

Protected areas are important for city's water supply and additional areas are managed to protected water sources

Tokyo uses a daily volume of 6.23 million m^3 water. River water provides most of the water resources, with groundwater resources accounting for just 0.2 per cent of the water supply. The Tone and Ara River systems supply 78 per cent and the Tama River system provides 19 per cent of the water resources from rivers. Most of the headwaters upstream of dams are located in areas designated as national parks. Designation, however, was not intended for conserving sources of drinking water. Nikko National Park (Category V, 140,698 ha), north of Tokyo, is in the watershed for the Tone and Ara river system. The oriental deciduous forest supports conserable biodiversity including the Japanese macaque (*Macaca fuscata)*, Asiatic black bear (*Selenarctos thibetanis japonicus)* and Honshu sika (*Cervus nippon centralis)*[127].Chichibu-Tama National Park (Titibu-Tama) National Park (Category V, 121,600 ha) is situated 50km north-west of Tokyo. Four main river systems originate in the parks mountains: Fuefuki, Tanba/Tama, Kawamata and Nakatsu/Arakawa. The parks proximity to Tokyo is resulting in a number of threats, including visitor pressure, the damming of two major rivers within the park (at Chichibu and Okutama) to provide hydro-electricity for the Tokyo area and cement factories. The forests are exploited and the more remote areas are gradually being opened up with forest road construction[128]. The Bureau of Waterworks of the Tokyo Metropolitan Government manages the forest at the source of drinking water in the upper reaches of the Tama River, at elevations of 500 to 2100 m. The forest extends about 31 km from east to west and about 20 km from north to south. The area of the forest at the source of drinking water is about 216 km^2, occupying 44 per cent of the basin of the Tama River. The forests are managed to: increase capacity to recharge water resources; prevent sedimentation in the Ogochi reservoir; increase water purification capacity; and conserve the natural environment[129].

10. Tehran, Iran
Protected areas play no role in supplying the city with water
Roughly 60 per cent of the water comes from three large reservoirs and the rest from groundwater sources[130].

11. Beijing, China
Some forested areas are managed for water shed protection
Beijing is located in the northern part of the North China Plain. Supplying water to the capital has been a problem for centuries, with Guo Shoujing, a river conservancy expert in the 13th century, mapping out the first system of water resources for the area[131].Today, planners estimate that the city faces an annual water deficit of about 1 billion cubic metres. Watersheds above the Miyun reservoir are a principal source of surface water for Beijing. The areas are designated to be managed for water protection, but under the principle of multiple use. Of the 3,298ha watershed about 813 ha, on steeper hill slopes, is managed as conservation forest land and protected from harvesting[132].

12. Krung Thep (Bangkok), Thailand
Minimal protection of watershed a considerable distance from the city, but the need for more protection recognised
The headwaters of the Chao Phraya river originate in mountainous terrain in the northern part of the country and consist of four large tributaries, the Ping, Wang, Yom and Nan rivers. The main river system passes through or close to many of the major population centres of the country including Bangkok, which is situated at its downstream end. The Chao Phraya basin is the most important basin in Thailand[133]. Some 77 per cent of the original forest cover has been lost and only 12 per cent of the watershed is protected. Forest covers 36 per cent of the watershed and 46 per cent is cropland (92 per cent of which is irrigated)[134]. The majority of forest cover occurs in the northern sub-basins where the percentage of forest ranges from 50-75 per cent in Ping, Wang, Yom and Nan to 30 per cent in Pasak and only 7 per cent in Chao Phraya. In recent years there has been steady encroachment of people into forest areas for conversion to agricultural purposes while cultivated land near urban centres has been converted to residential or industrial use. The need to protect the upper catchment of the Chao Phraya basin from degradation and soil erosion has been identified as a priority by government[135].

13. Lahore, Pakistan
Protected areas play no role in supplying the city with water

14. Kolkata (Calcutta), India
Protected areas play no role in supplying the city with water
The majority of Calcutta's water comes from the River Hooghly along with some groundwater sources[136].

15. Baghdad, Iraq
Protected areas play no role in supplying the city with water
Most water is extracted from the Tigris and Euphrates rivers.

16. Chennai, India
Protected areas play no role in supplying the city with water
Surface reservoirs, i.e. Red Hills, Poondi and Tamarapakkam, supply drinking water to Madras[137]. However, current water supply only meets just over a quarter of the demand, leading to the city authorities going as far as 400 kms from the city to procure water [138].

17. Tianjin, China
Protected areas play no role in supplying the city with water
Tianjin is located on the downstream portion of the Haihe Basin in the northern apex of the Great North China Plain. Surface water is being contaminated by Beijing's upstream activities[139].

18. Pusan, Republic of Korea (South)
Protected areas play no role in supplying the city with water
T'aebaek Mountains form the backbone of the Korean peninsula, extending southward from Wonsan in North Korea almost to Pusan on South Korea's southeastern coast. The mountains form the countries main watershed[140].

19. Yangon (Rangoon), Myanmar
Some forested areas are managed for watershed protection
Two dams in Teikgyi Township, Gyobyu and Phugyi, are the main supply of drinking water to Yangon. Their watersheds are primarily forested (Gyobyu covers 3344 ha, of which 2,068 ha is forested and Phugyi 6176 ha, of which 5,042 ha is forested). The Gyobyu reservoir is protected as a recreation area. The Forest Department of Myanmar is responsible for forest conservation activities in the watersheds, and is currently restoring forest cover around the dams (to date, 304 ha have been planted around Gyobyu dam and 1,608 ha around Phugyi dam)[141].

20. Wuhan, China
Protected areas play no role in supplying the city with water
Wuhan is the capital of the Hubei Province, which lies in the middle Yangtze River valley. The Yangtze River and one of its largest tributaries, the Hanjiang River, are the main water sources for the city[142].The Yangtze watershed covers some 1.7 million km^2, with a population density of 224 people per km^2. 85 per cent of the original forest cover has been lost, and only 2 per cent of the watershed is protected. 11 per cent of the watershed is forested, 56 per cent is cropland and 22 per cent grassland[143].

21. Ahmadabad, India
Protected areas play no role in supplying the city with water
Most of the city's water comes from groundwater sources[144].

22. Hyderabad, India
Some protection of watershed a considerable distance from the city
About 850 million cubic metres of water are stored from the Majeera river for the domestic use in Hyderbad city. Manjeera river is a tributary of the Godavari river (Godavari basin), which has its source in the Western Ghats forests (which contain several protected areas such as: Eravikulam National Park, Category II, 9,700 ha; Silent Valley National Park, Category II, 8,952 ha). Currently about 500 million litres a day are supplied to the city[145].

23. Bangalore, India
Protected areas play no role in supplying the city with water
Water comes mainly from the Arkavathy River and the Cauvery River.

24. Singapore (see case study)
Protected areas are important for city's water supply
Half of Singapore's water comes from the Central Catchment Reservoirs. Bukit Timah (Bukit Timah and the Central Catchment Area – 2,796 ha), in the centre of the Island, are Category IV protected areas. The island state receives the other half of its approximate 300 million gallons of water per day usage from Johor in Malaysia.

25. Ar-Riyad (Riyadh), Saudi Arabia
Protected areas play no role in supplying the city with water
Most of the country's drinking water comes 33 desalination plants, which supply 3.5 billion gallons a day, equivalent to 70 per cent of drinking water needs. Other sources include groundwater reservoirs and almost 200 dams have been built to store rainwater[146].

The Americas

26. Buenos Aires, Argentina
Protected areas play no role in supplying the city with water
Buenos Aires sources its water from the Rio de la Plata, which is the final segment of the massive Paraná River System. The water is collected from the source, transported to large cleaning pools where it is then purified and distributed throughout the city. No protected areas contribute to the production and quality of the Rio de la Plata water. There are some protected areas and reserves along the lower course of the Paraná River, but they have been created with the main purpose of protecting selected components of the biodiversity[147]. The Paraná watershed covers over 2.5 million km^2 over 4 countries and contains 54 large cities (with populations over 750,000). Forest covers only 12 per cent of the land and over 70 per cent of the original forest has been lost. Only 3 per cent of the watershed is protected[148].

27. São Paulo, Brazil
Protected areas are important for city's water supply
São Paulo's 18 million inhabitants depend heavily on some key protected areas for their drinking water. Primary among these is the Cantareira State Park (Category II, 7,900 ha). The Cantareira catchment, located in the outstanding remnants of the highly endangered Atlantic forest, provides 50 per cent of the water supply to the Greater São Paulo Metropolitan area, and the State Park is of central importance for its protection. The 58,280 ha area known as Billings includes São Paulo's single largest water reservoir. From 1989 to 1999, 6 per cent of the area was deforested. Currently, 53 per cent of the area is still covered by native vegetation. Guarapiranga Ecological Park, Morro Grande State Reserve, Itapeti Ecological Station, Juquery and Alberto Loefgren State Parks are also all important for maintaining São Paulo water supply. Ensuring the management of the system is a daunting challenge. Urban encroachment on protected areas, degradation of soil and water catchment, water pollution, irrigation and water for energy are just a few examples of conflicting uses that need to be balanced.

28. Mexico City, Mexico
Protected areas play no role in supplying the city with water
Mexico City is in the southern part of the Basin of Mexico, an extensive, high mountain valley. Ground water is the main water source. The Sierra Chichinautzin is the most important natural recharge zone for the Mexico City Aquifer due to the high permeability of its basalt rock. By the 1930s, continued subsidence and the realisation that ground water supplies within the Basin of Mexico were being depleted prompted authorities to explore sources of water outside the basin. In 1982, an ambitious project was initiated that delivered surface water from the Cutzamala River Basin, a distance of 127 kilometres from the city[149].

29. New York, USA (see case study)
Protected areas and areas managed for watershed protection are important for city's water supply
The Catskill, Delaware and Croton watersheds deliver 1.3 billion gallons of water per day to New York City and the metropolitan area[150]. The Catskill/Delaware Watershed, northwest of New York City, provides 90 per cent of the City's drinking water. The Catskill State Park (Category V, 99,788 ha) protects the watersheds of the Catskill/Delaware system[151].

30. Lima, Peru
Protected areas play no role in supplying the city with water
Water supply is provided by a combination of groundwater and treated surface water taken from the Rimac River that flows from the Andes.

31. Bogotá, Colombia
Protected areas are important for city's water supply
Bogotá's water supply is derived from three main components. The main water source for the city (about 70 per cent) is the Chingaza system, located 50 km east from Bogotá. It collects water from the Guatiquía, Blanco, and Teusacá Rivers into two large reservoirs: the Chuza and San Rafael Dams. Both its integrity and functioning largely depend on the conservation of the watersheds involved within the Chingaza National Park (Category II, 50,374 ha). The second component is the Bogotá River system. It collects water from the upper watershed of this river and stores it in three reservoirs: the Sisga, Tominé and Neusa dams. The third component, the Tunjuelo System stores water from the Tunjuelo, San Francisco and San Cristobal Rivers in two dams: Chisacá and La Regadera[152].

32. Rio de Janeiro, Brazil (see case study)
Protected areas are important for city's water supply
Fourteen different protected areas and the Atlantic Rainforest Biosphere Reserve help to protect the sources of water for the main Guandu Water Treatment Facility, which provides over 80 per cent of Rio de Janeiro's water. Within the Rio de Janeiro Metropolitan area there are a further four protected areas protect areas, which were once the city's main sources for water, but which now only provide just under 10 per cent of the supply. The remaining 10 per cent of the city's water comes from the Lages reservoir, which has forest managed under the regulations established by the Forest Code.

33. Santiago, Chile
Areas in the metropolitan area have been slated for protection and there is also protection of the watershed a considerable distance from the city
Chile's national capital, Santiago, is dominated by a mountainous landscape estimated to cover some 85 per cent of the metropolitan region. The most important sources of water for Santiago are the Maipo River and the Laguna Negra (76 per cent) which run from Laguna Negra volcano in the Andes. The river basin covers some 15,000 km^2 and the main river runs for about 250 km. The water from this river comes from melted snow in the mountains. Other minor contributors are Mapocho River (4 per cent), Molina River, the Yerba Loca estuary, the San Francisco River and the Arrayan estuary. Surface water represents 80 per cent of the water used in the city and underground water contributes 20 per cent. There is considerable protection at the sources of the rivers, with a national park, national reserve and the nature sanctuaries located in the mountain range where little agriculture activity occurs (Cerro el Morado National Park (3,000 ha); Rio Clarillo Nacional Reserve (Category IV, 10,185 ha); Nature Sanctuaries (Predio Los Nogales, Predio Yerba Loca, Quinta Normal) (25,100 ha), total area of scientific interest (11,275 ha) and protected areas (820,947 ha)[153]. Chile's matorral ecosystem is the only example of Mediterranean scrub ecoregion found in all of South America and is only one of five such ecosystems in the world. Within Latin American and the Caribbean region, this ecosystem has been designated as a high-priority in terms of the need to conserve its biodiversity. The only representative sample of this important ecosystem is Chile's Rio Clarillo National Reserve, which represents only some two per cent of the ecosystem's total area.

In 1997, the National Commission for the Environment (Comisión Nacional de Medio Ambiente) conducted a survey that identified the Santiago Foothills, a primary example of the Chilean matorral ecosystem, as of 'singular relevance in terms of its biodiversity'. In 1998, the Ministry of Housing and Urban Development (MINVU) commissioned a survey of potential natural sites in the Santiago metropolitan area to be considered for conservation status. The results of the

survey indicated that 19 out of the 24 sites surveyed were located in the Foothills and confirmed the importance of this ecosystem in the metropolitan region. The Metropolitan Santiago Master Plan (PRMS) administered by MINVU thus classified the Santiago Foothill ecosystem as an 'Ecological Conservation Area', to be "preserved in natural condition, in order to ensure and contribute to environmental balance and quality". A proposed project area of 12,900 ha, bordered by hills to the west which limit the further expansion of Santiago's urban development, the Mapocho and Maipo rivers to the north and south respectively, and a mountain range to the east, is being supported by the World Bank. In the past, the Foothills were used for extensive grazing, topsoil extraction and extraction of firewood and coal from existing sclerophyllous vegetation. Over time, these historical uses have contributed to a reduction in vegetative cover and soil degradation, which in turn are thought to have contributed to a change in the area's hydrology and exacerbated downstream water quality conflicts. The major economic activities in the area are grazing, fruiticulture, and provision of potable water (*Empresa Metropolitana de Obras Sanitarias* which supplies potable water for part of the municipal district of La Reina) which represents about 20 per cent of potable water in Santiago[154].

34. Los Angeles, USA

Protected areas are important for city's water supply

The Eastern Sierra watershed, comprised of the Owens Valley and Mono Basin watersheds, is an approximately 891,000 ha watershed which supplies the city of Los Angeles with water. The U.S. Forest Service, U.S. Bureau of Land Management and the Los Angeles Department of Water and Power (LADWP) own 98 percent of this land[155]. Many of California's national forests were created specifically to safeguard and preserve water supplies. The Angeles National Forest is one of 18 national forests in the Pacific Southwest Region of the US Department of Agriculture-Forest Service. The eighteen national forests in California cover only 20 per cent of the land in the State but produce almost half the State's runoff water[156]. The Angeles National Forest (Category VI, 265,354 ha), was established in 1892 and is administered by the US Forest Service. Part of an rugged range rising to over 3,000 m, its lower slopes are covered with chaparral; higher elevations have mixed conifer forest. Within the Angeles National Forest are wilderness areas totalling 32,500 ha and several strictly protected areas, including the 6,900-ha San Dimas Experimental Forest, a biosphere reserve managed for research and generally closed to the public; within it is the 555-ha Fern Canyon Research Natural Area, an oak woodland held as a control for studies on erosion, fire, and air quality[157].

35. Chicago, USA

Protected areas play no role in supplying the city with water

Chicago's water comes from Lake Michigan (one of the Great Lakes) and is not protected[158, 159.]

36. Toronto, Canada

Protected areas play no role in supplying the city with water

Toronto's water comes from Lake Ontario, which is not a protected area in any formal way[160].

37. Salvador, Brazil

Protected areas are important for city's water supply

Two recently created protected areas provide drinking water to the metropolitan region of Salvador. The Lago de Pedra do Cavalo Environmental Protection Area (Category V) was created in 1997, and helps protect caatinga and riverine forests that are vital for the protection of the artificial lake that has been built to ensure the water supply to Salvador and other cities in its vicinity. The Joanes/Ipitinga Environmental Protection Area (Category V, 60,000 ha) protects mangroves, Atlantic forest relicts, and a network of rivers that ensure the provision of nearly 40 per cent of potable water to the metropolitan region of Salvador. Typical problems related to the conservation of these areas are: water contamination by uncontrolled domestic and industrial sewage, unplanned and illegal land occupation, deforestation and forest fires.

38. Havana, Cuba

Protected areas play no role in supplying the city with water

The water supply for the city of Havana comes from underground water aquifers developed in karstic areas that are about 20-30km from the city. Upper parts of the aquifers are protected from pollution by regulation to control activities that would limit their capacity to absorb water filtering from the soils. These regulations are strictly controlled and applied by the Ministry of Water Resources. However these "aquifer protective zones", as they are known in Cuba, are not classified as protected areas as they do not relate to areas of biodiversity value[161].

39. Belo Horizonte, Brazil

Protected areas are important for city's water supply

A network of 10 forest reserves ensures the provision of drinking water to the over 3 million inhabitants in the metropolitan area of Belo Horizonte. Together, the reserves of Mutuca, Fechos, Rola-Moça, Taboões, Catarina, Bálsamo, Barreiro, Cercadinho, Rio Manso and Serra Azul cover 17,000 ha of protected forests, under different IUCN categories and protective forest regimes.

40. Fortaleza, Brazil

Protected areas play no role in supplying the city with water

The water scarce region of Fortaleza relies on a complex system of dams, channels and wells for its drinking water supply. COGERH is the institution responsible for the provision of water to Fortaleza's more than two million inhabitants. Although currently there are no clear links between protected areas and the provision of drinking water, there is a need to ensure that key areas of some river basins, such as the Cocó and Pacoti Rivers, are strategically protected for water provision in the future.

41. Cali, Colombia

Protected areas are important for city's water supply

Cali sources its drinking water from several sources including Farallones de Cali National Park (Category II, 150,000 ha), one of the oldest parks in the country[162]. Cali is surrounded by seven rivers (Aguacatal, Cali, Cañaveralejo, Cauca, Lili, Melendez and Pance). However, most of them are under threat from pollution. The Cauca River watershed is the main source of water, and where most of the city's waste is disposed off. Serious water level reductions in the watershed, have recently led to the water companies to ask for more rational use of the resource (July 21, 2003). There are proposed projects for a total US$200,000 million to recuperate the Cauca River basin[163].

42. Guayaquil, Ecuador

Protection of watershed a considerable distance from the city

The major source of freshwater is the Guayas River, which forms 60 km upstream at the confluence of the Daule and Babahoyo rivers[164]. Although drinking water for the city does not come directly from protected areas, water sources in the lowlands receive water from the Western slopes of the Andes. Here there are several protected areas and other forms of protected forests, so that protected watersheds play some role in the overall water supply. Drinking water problems relate more to increased levels of salt, which one theory proposes is occurring because of rising sea levels and consequent forcing of saline water further into river systems. The mangroves that might provide a natural barrier to this water flow have been heavily degraded in the Guayaquil Gulf area, suggesting that restoration of mangroves might help overall drinking water quality[165].

43. Brasília, Brazil

Protected areas are important for city's water supply

Brasília National Park (Category II, 28,000 ha) was created to protect one of the most important sources of water for Brasília. Planned for 400,000 inhabitants, the Brazilian capital now has a population of over two million. About 40 per cent of the drinking water in the city itself is supplied

directly from the National Park[166], which comprises of upland tree savannah or cerrado and campo cerrado with gallery forests around the springs and watercourses. The area is also a much appreciated recreational site for the city dwellers

44. Santo Domingo, Dominican Republic
Protected areas are important for city's water supply
It is estimated that 52 per cent of the population of the Dominican Republic do not have access to potable water. The main sources of water for Santo Domingo are located in the Caribbean watershed, the source of the rivers Yuna and Nizao, Yaque del Sur, San Juan and Mijo. Many of the rivers are being polluted by sewage, agriculture and industry. The Madre de las Aguas (Mother of the Waters) Conservation Area, consists of five separate protected sections covering more than 323,760 ha: Armando Bermúdez National Park (Category II, 76,600 ha), Juan B. Pérez Rancier (Valle Nuevo) National Park (Category Ia, 40,900 ha), José del Carmen Ramírez National Park (Category II, 73,784 ha), Nalga de Maco National Park and Ebano Verde Scientific Reserve (Category Ia, 2,310 ha). The Madre de las Aguas shelters the headwaters of 17 rivers that provide energy, irrigation and drinkable water for more than 50 per cent of the country's population. The area ranges in elevation from 1,000 to 3,087 meters, making for a high degree of habitat diversity and endemic species. About 90 per cent of the conservation area's amphibian and reptile species, 43 per cent of the butterfly species, 10 per cent of the bird species and 94 per cent of the bat species are unique to the area. About 40 per cent of plant species in the conservation area are endemic. Hispaniolan pine forest covers much of the region, as well as manacla forest, named for an endemic palm tree that is critical in maintaining amphibian, reptile and bird populations. Cloud forests are the origin of fresh water for much of the country's river systems while montane broadleaf forests provide protection to waterways at lower elevations. At the beginning of the 1900's, forest covered around 85 per cent of total area of the country but by 1986 only just over 10 per cent remained forested. Since the 1960's, the government has prohibited deforestation in an effort to protect forest resources, but even protected areas remain under threat. Unsustainable logging, uncontrolled fires, slash and burn agriculture, expansion of sun-grown coffee fields and hillside farming are causing soil erosion and significant species loss in the conservation area[167].

45. Houston, USA
Protected areas play no role in supplying the city with water
Two-thirds of the drinking water provided to Houston residents comes from the Trinity River via Lake Livingston and the San Jacinto River via Lake Houston and Lake Conroe. The EPA's Index of Watershed Indicators has determined that a major Houston-area watershed, the Buffalo-San Jacinto Watershed, has serious contamination problems[168].

46. Medellín, Colombia
Protected areas are important for city's water supply
The Medellín River basin is the main source of water for the city. The origin of the basin is located in the Central Andes Mountain Range, where the Alto de San Miguel Recreational Park and Wildlife Refuge (721 ha), protects the source of the River. Traditionally the park area has been influenced by poor agricultural practices and more recently, logging activity in the neighbouring area. In addition, the water supply for Medellín and neighbouring settlements has three large subsystems known as La Ayurá, Manantiales and Piedras Blancas, with four processing plants and three dams. All of these components are interconnected to some extent. All of these areas have some degree of protection even though none of them is included in a National Park[169].

47. Caracas, Venezuela (see case study)
Protected areas are important for city's water supply
The city receives water form three main sources. These sources correspond to three national parks, the Guatopo (122,464 ha, Category II), the Macarao (15,000 ha, Category II) and the Avila National Park

(85,192 ha, Category II). All three parks are recognised as areas of hydrological importance that contribute to providing water for the city[170].

48. Guadalajara, Mexico
Protected areas play no role in supplying the city with water
Guadalajara is Mexico's second largest city, with over 3.5 million inhabitants. The city faces serious water shortages, as it prime water source, Chapala Lake – the largest natural lake in Mexico, is drying up. The lakes water level has been dropping for years, mainly due to poor water management, reaching a low point of only some 23 per cent of it capacity in 2001. Furthermore, about 40 per cent of the water that runs through the water distribution system in the city is wasted because of leaks. An alternative project to use a new source of water (Verde River) has not been approved by the authorities. There is also a project to build a new aqueduct for the city but it will require the relocation of local residents. Chapala Lake is fed by the Lerma-Santiago river basin, which has also suffered great decreases in flow due to water withdrawals upstream. The water that runs through this basin is one of the most polluted in the country. More positively, new educational campaigns are being started to recuperate the lake and a proposal exists to declare the lake a RAMSAR site. Presently it has been included as part of the network of Living Lakes[171].

49. Maracaibo, Venezuela
Protected areas are important for city's water supply
Up until 1938 the city took its water from the Lake Maracaibo. Currently the city receives water from the Mara and Paez basin, however the supply is becoming insufficient due to deforestation in the highlands of the basin and the growth of the city. Further supplies come from the Catatumbo basin which originates in Colombia. Authorities estimate that water from rivers in the southern part of the state could be used to fulfil the city needs, also rise in Colombia and are subject to significant pollution. Part of the mountain range where the Mara and Paez rivers originate is protected by the Perijá National Park (Category II, 295,288 ha), in the Perijá Mountain Range. The Perijá National Park has serious management problems due to the presence of Colombian armed groups, illegal crops, conflicts among Creole cattle people and the native communities, coal mining, and the advancement of the agricultural frontier (the last three issues occurring mainly in land adjacent to the park). Recent reports mention that heroin trafficking groups have deforested up to 2,000 ha to plant poppy fields, threatening the park's rare howler and capuchin monkeys, spectacled bears, wood storks and giant anteaters. The Perijá National Park is contigous with the Catatumbo-Barí National Park in Colombia (Category II, 158,125 ha)[172].

50. Ecatepec, Mexico
Protected areas play no role in supplying the city with water
The Monctezuma River basin and the sub-basin of the lakes Texcoco and Xaltocan are the main sources of water for the city. Although the area close to the city has a limited capacity of underground water, it is not used because 80 per cent is diverted to Mexico City[173].

Europe

51. Istanbul, Turkey (see case study)
Official protected areas currently play no role in supplying the city with water
There are several water reservoirs in the forests on both peninsulas of Istanbul which have been providing water for the city for several centuries The role of these reservoirs in providing potable water to the city is 'very significant'. However these forests are not classified as protected areas, although WWF-Turkey is currently lobbying the authorities to declare them as protected.

52. Moscow, Russia
Low levels of protection around areas supplying the city with water
Drinking water for Moscow comes from the Moscow and Volga rivers through a system of channels and reservoirs, which have protected buffer zones (although they are not formally included in the system of protected areas). Forests on the river banks, around lakes and reservoirs that are used for drinking water supply, help ensure water quality and quantity. These protective zones correspond to IUCN category VI. In the Moscow region, protective zones for drinking water represent more than 10 per cent of the forested area of the region (while the average figure for Russia is 0.15 per cent).

53. London, United Kingdom
Protected areas play no role in supplying the city with water
London's sources its water supply by abstraction from the River Thames and River Lee and pumping into fully impounded reservoirs in south west and north London respectively[174].

54. St Petersburg, Russia
Protected areas play no role in supplying the city with water
Water comes mainly from the River Neva.

55. Berlin, Germany
Water sources are protected through special protection zones
Nine waterworks supply Berlin with drinking water drawn entirely from groundwater sources, all of which are surrounded by protection zones. The boundaries of the conservation areas are set by isochrones, i.e. lines marking similar flow times to the well. In these protection zones, which are in three different degrees of protection and generally have a radius of a few hundred metres, activities likely to endanger eater supplies are prohibited[175].

56. Madrid, Spain
Protected areas are important for city's water supply
Madrid's water supply comes from 15 dams, all of them located in the northern area of the province (Sierra Guadarrama). Five out of these 15 dams, belonging to the Lozoya River Basin, which provides two-thirds of the total freshwater supplies (El Atazar, El Villar, Puentes Viejas, Riosequillo and Pinilla dams) none of these dams are in protected areas although the Lozoya's River watershed includes some important ecological areas. The upper part of this basin has recently been protected (Natural Park of Peñalara). The new 15,000 ha Natural Park was announced in 2003, and provides protection to Madrid's only glacier lake. The site will provide protection to the area's wildlife, regulate building and sanitise effluents into the river Lozoya[176]. One dam (Santillana) takes water from the Manzanares River Basin, which is included in the Regional Park Cuenca Alta del Manzanares (Category V, 46,323 ha)[177].

57. Rome, Italy
There are a number of protected areas in the watershed
The water system which supplies Rome and 60 other councils in Lazio is comprised of seven aqueducts, adding up to more then three hundred kilometres. Rome is one of the few cities in the world whose water supply is naturally potable, since the sources are particularly pure. 97 per cent of potable water comes from natural sources while the remaining 3 per cent comes from wells[178]. There are several protected areas in the watershed.

58. Kyyiv (Kiev), Ukraine
Protected areas play no role in supplying the city with water
Kiev does not source any of its potable water from protected areas. In Ukraine, in general most surface and underground water resources originate from the Dnipro (Dnieper) River, which supplies water to

two-thirds of the Ukrainian population and 60 per cent of Ukraine's farms. The watershed of the Prypyat River, a tributary of the Dniper River, is a wetland area which is likely (after Chernobyl) to be established as a National Park (currently being proposed as part of a GEF grant)[179]. Very little of the watershed (only some three per cent) is forested, and in 1998 only two per cent was protected[180].

59. Paris, France
Protected areas play no role in supplying the city with water
Paris's water comes from rivers (including the Seine)[181].

60. Bucharest, Romania
Protected areas play no role in supplying the city with water
Water comes from the River Dambobitza and from groundwater sources.

61. Budapest, Hungary
Protected areas are present in the watershed
Seventy per cent of Budapest's drinking water comes from Szentendre island, north of the city. All the wells (100 wells) are drilled in the bank zone and they filter Danube water. The island is designated as a hydrogeological protection zone where land use is restricted. Duna-Ipoly National Park covers about twenty per cent of the island due to its natural values (regardless of the position of the wells)[182].

62. Minsk, Belarus
Protected areas play no role in supplying the city with water, however forest areas are managed to protected water sources
There are two sources of drinking water supply for Minsk: underground source and waters from the Vileya River which are transported through a system of channels and reservoirs. There is no obvious link between existing protected areas and drinking water supply, however, the green belt around Minsk (radius is about 80 km) and protective zone around the Minsk reservoir play a very important role in ensuring water quality. The protective regime in these zones is quite strict. For example, logging is prohibited. Thanks to these restrictions, the forest around Minsk city has not destroyed[183].

63. Hamburg, Germany
There are protected areas within the catchment
The drinking water supply in Hamburg is based upon ground water taken from 18 different waterworks, 14 of them located within the city borders and 4 in the outer region. The water catchment areas of two in the outer region have some protection status[184].

64. Warsaw, Poland
Protected areas play no role in supplying the city with water
Forty per cent of Polish forests have a water protection function. Warsaw takes it water from the Vistula, the watershed of which covers 70 per cent of Polands area. In total 10 per cent of the Vistula watershed (180,247 km^2) is protected[185].

65. Vienna, Austria
Protected areas are important for city's water supply
The Donau-Auen National Park (Category II, 10,000 ha) is a significant source of Vienna's drinking water (up to 20 per cent). The remainder is piped from mountain areas, where there are some protected forests but not official IUCN category protected areas[186].

66. Barcelona, Spain

Protected areas are important for city's water supply

Until 1950, almost all the water supplied to Barcelona came from wells in the Besòs and Llobregat deltas. With increased demand and spreading underground contamination, the city of Barcelona decided to import water from two rivers: the Ter (some 100 km north of Barcelona) and Llobregat, next to the city. Currently, 90 per cent of the water consumed in Barcelona city comes from surface water of these two rivers. In 1997, the public service, AGBAR, supplied 153 hm^3 of water, 41 per cent of which came from the Ter River, and the rest from the Llobregat River.

Water quantity is highly dependant on dams. Above the *Estació de tractament d'aigua potable* (water purification plant), the Ter River has three dams (Sau, Susqueda and Pasteral) with a capacity of 400 hm^3 per year. Above the purification plant, the Llobregat River has three dams (Baells, Sant Pons and Llosa del Cavall) with a combined capacity of 224 hm^3 per year. Water quality from these two rivers is not good. Water from the Ter River is treated at the water purification plant of Cardedeu, it then connects with the water of the Llobregat River, as well as the collecting wells of the Llobregat delta, and it is treated at the water purification plant of Sant Joan Despí, in the lower valley, only 15 km from the sea.Taste of tap water in Barcelona is generally poor. For this reason, Barcelona has a very high rate of bottled water consumption. Over 90 per cent of the bottled water comes from springs located in several Catalan protected areas, such as the Montseny Nature Park.

A large portion of both watersheds are forested and there are several protected areas, although the level of protection varies. In the Llobregat basin, over Sant Joan Despí, where water is taken (although some water is taken a little above, from Abrera), the protected areas are:

- Parc Natural Serra del Cadí-El Moixeró (part) (Category V, 41,342 ha),
- Paratge Natural d'Interès Nacional del Pedraforca (Category V 1,671 ha)
- EIN Serra de Catllaràs
- EIN Serra de Picancel
- EIN Serra d'Encija-Els Rasos de Peguera
- EIN Serres de Busa-Els Bastets
- EIN Serra de Queralt
- EIN Els Tres Hereus
- EIN Serra de Navel
- EIN Muntanya de Sal de Cardona
- Parc Natural de Sant Llorenç del Munt i Serra de l'Obac
- Parc Natural de Montserrat
- EIN Roques Blanques
- EIN Serra de Collserola (part)
- EIN Muntanyes de l'Ordal

Natural protected areas in the Ter basin, over El Pasteral (where water is taken, after three dams: Sau, Susqueda and El Pasteral), are:

- EIN Capçaleres del Ter-Freser
- EIN Serra de Montgrony
- EIN Obagues de la Vall de l'Isard
- EIN Serra Caballera
- EIN Serres de Milany, Serres de Santa Magdalena i Puigsacalm-Bellmunt (partially)
- EIN Collsacabra (part)
- EIN Savassona
- EIN Les Guilleries
- EIN Riera de Sorreigs
- EIN Turons de la Plana Aussetana

EIN= *Espai d'Interès Natural* (created in 1992 by the *Pla d'Espais d'Interès Natural,* passed by the Government of Catalonia). Protection level equivalent to IUCN Category V protected landscapes.

Most of protected areas in these two basins are forested until 2200-2300m, above this altitude alpine meadows dominate. Except for those protected areas that have higher levels of protection, such as *Parc Natural* or *Paratge Natural d'Interès Nacional*, there not a significant difference in forest management whether the area is inside or outside an EIN. The main problems of water quality and quantity are related to multiple urban, industrial and agricultural uses and impacts above the points were water is taken in both rivers. For instance, the middle Ter basin, just above the dam of Sau, has the highest concentration of cattle of Spain, which causes widespread contamination of ground and underground waters. On the other hand, the lower Llobregat valley is one of the most important industrial areas of Catalonia. Global-climate experts agree that in this Mediterranean region annual precipitation will decrease by around 20 per cent by the year 2050. From now to then, they think there will be an increase of the frequency of intense precipitation events; flood hazard, and risk of water shortage, especially during summers[187].

67. Kharkov (Kharkiv), Ukraine
Protected areas play no role in supplying the city with water
Water comes from several surface sources including the rivers Ouda and Seversky Donets.

68. Nizhnij Novgorod, Russia
Protected areas play no role in supplying the city with water

69. Milan, Italy
Protected areas play no role in supplying the city with water
An aquifer system, which is the source of drinking water for the city of Milan, and extends over an area of about 400 km^2[188].

70. Ekaterinburg, Russia
Protected areas play no role in supplying the city with water
Most of the water comes from surface waters and groundwater sources are very limited.

71. Stockholm, Sweden
Protected areas play no role in supplying the city with water, but the watershed is managed for water quality, and some forest activities are FSC certified
Stockholm, the capital of Sweden in northern Europe, has a population of over 1.8 million (1999), just over 20 per cent of the countries population, in an area of about 6,500 km^2. The area is experiencing slow, but sustained, population growth. In 1999, the population increased by 1.1 per cent[189], and the region expects to house 4-600,000 more inhabitants within the next 30 years[190]. Water supply and sewage disposal in Sweden are by law a municipal responsibility[191]. In Stockholm, the local authority-owned company Stockholm Vatten delivers fresh water to Stockholm residents and ten neighbouring municipalities. The company owns and manages two fresh-water plants, three sewage purification plants, sewers for fresh water and sewage water and pumping stations in the Stockholm area[192]. In 2002, water production totalled 133.1 million m^3 and is reported as being of 'consistently high' quality[193].

Lake Mälaren is the water source for the Norsborg and Lovö waterworks, the cities main water providers. Lake Bornsjön, which was bought by the city in 1904, is the backup water source in the event of any temporary problem in Lake Mälaren[194]. Stockholm Vatten controls most of the 5,543 ha watershed of Lake Bornsjön, of which 2,323 ha, or about 40 per cent, is productive forestland[195].

Although forestry is conducted in the Lake Bornsjön watershed, Stockholm Vatten's management is focused on protecting water quality. This objective has a major effect on forestry practices, with management concentrating on measures to reduce soil erosion into the lake. Thus many trees are left standing to protect water courses and lakes and no scarification is carried out to avoid ground damage by heavy machinery. The main species grown and harvested are spruce (*Picea abies*), pine (*Pinus silvestris*) and birch (*Betula* sp.). Forest management is also to a large extent adapted for recreation purposes, and the forest has many areas of cultural significance which are also taken into consideration by forest management[196]. In September 1998, Stockholm Vatten was certified under the Swedish Forest Stewardship Council (FSC) standard[197].

As the role of the state declines in many countries, the importance of conservation initiatives by the private sector will increase. One important aspect of this is the role that commercial companies could play in protected areas. Companies can provide support to national protected area networks in a number of ways, ranging from providing financial, logistic or technical support for existing protected areas, to sympathetic management of buffer zones or even putting aside some of their own land into protection[198]. Forests cover around 60 per cent of Sweden's land area, but only 4,4 per cent of Sweden's total productive forest land is protected and in most regions of southern and middle Sweden is the figure below 1 percent[199]. Although the need for more protection of biologically-important forest areas is now generally recognised, the Swedish authorities have tended to put an emphasis on voluntary policies which work with forest owners in increasing protected area networks rather than relying on new legislation. A survey of voluntary protected areas in 1996 showed that a fifth of all the private forest owners and all large companies had established voluntary reserves. According to the Swedish National Board of Forestry and the Environmental Protection Agency, such reserves were expected to protect about 2-4 per cent of forest below montane forests, however they noted that '*information on voluntary reserves is, in many ways, unreliable and preliminary. Therefore, it is important to study them more closely to find out about their extent and their environmental values*'[200].

The voluntary nature of company protection has been further refined through independent certification of forest management. The Swedish FSC standard was endorsed in 1997 – the first national FSC standards in the world. The standard addresses a broad range of issues relevant to forest management in Sweden. Some important environmental components include protection for so called key habitats and old-growth forests (including restoration incentives), protection of mountain forests from further fragmentation and modified management and restoration of deciduous forest types[201]. The Swedish standard says that FSC certified management units must include protection for a range of important forest habitat sites within commercial holdings. At least 5 per cent of certified land (excluding very small areas and areas already legally protected and compensated for by the state) must be exempt from forest management – thus standardising the earlier proposals for protected area targets[202]. According to the certification report for Stockholm Vatten's Lake Bornsjön watershed, areas left for conservation and restoration *'will considerable exceed 5 per cent of the productive land'*[203].

72. Praha (Prague), Czech Republic

Protected areas play no role in supplying the city with water

Water comes from the Zelivka and Vltava rivers and from groundwater sources.

73. Munich, Germany

Protected areas play no role in supplying the city with water, but forests in the watershed is managed for water quality

Since the foundation of the Munich waterworks in circa 1900, forest management and the issuing of forestry-licences has been focussed on ensuring good water quality. Today, an area of 2,900 ha is managed primarily to maintain water quality and an additional area of 1,900 ha is under long-term contracts with local farmers, who commit to certified ecological/organic agriculture[204].

74. Samara, Russia
Protected areas play no role in supplying the city with water

75. Sofija, Bulgaria
Protected areas are important for city's water supply
Sofia relies for much of its water supply on sources originating from two mountain protected areas: the Rila (Category II, 107,924 ha) and Vitosha (Category IV, 26,607ha) National Park. Within the Parks are a number of higher IUCN category protected areas. For example, much of the water for several residential areas of Sofia is drawn from the Bistrishko Branishte Biosphere Reserve (Category Ia 1,062 ha), a high mountain peat bog area within Vitosha National Park, which is a Strict Reserve, a Biosphere Reserve and a drinking water protection zone [205]. The reserve comprises of coniferous forests mostly with spruce (*Picea abies*) and deciduous forests of beech (*Fagus sylvatica*) on lower slopes, whereas the higher parts are covered by subalpine shrub (*Juniperus sibirica*) and grassland communities. The botanical diversity is rich – more than 400 species of algae, 360 lichens, 500 fungi and 450 vascular plants have been recorded. The reserve is also home to many rare and endangered animals such as the brown bear (*Ursus arctos*), *Spermophilus citellus*, marten (*Martes martes*), *M. foina*, *Mustela nivalis* and wolf (*Canis lupus*). The forest was subject to timber exploitation until the establishment of a nature reserve[206].

Africa

76. Lagos, Nigeria
Protected areas play no role in supplying the city with water
Water comes from both surface and groundwater sources.

77. al-Qahira (El Qahira), Cairo, Egypt
Protected areas play no role in supplying the city with water
All three of Egypt's biggest cities lie at the end of the Nile watershed. Over the centuries the watershed has lost 91 per cent of its original forest cover and now has only 2 per cent forest cover (crop land accounts for just 10 per cent, grassland 52 per cent and 30 per cent is barren). The watershed has 7 large dams on it, and 30 large cities within it. Only 5 per cent is protected[207]. Some protected areas such as Mount Elgon in Kenya (Category II, 16,923 ha), Rwenzori (Category II, 99,576 ha), Queen Elizabeth National Park (Category II, 197,752 ha), Kibale Forest Corridor (IV, 33,918 ha) and Semliki Controlled Hunting Area (Category VI, 50,400 ha) and Murchison Falls National Park (Category II, 383,907ha) in Uganda feed into the Nile[208], but clearly have little influence on the quantity or quality in countries thousands of miles away.

78. Kinshasa, Congo (Dem. Rep.)
Protected areas play no role in supplying the city with water
Kinshasa is situated on the banks of the Congo River (also known as the Zaire). The Congo is the fifth-longest river in the world; it stretches over 4,000 km and its watershed covers over three million km^2. Its hydrological system straddles several countries (Congo and the Democratic Republic of Congo for the most part, but also Angola, Cameroon, the Central African Republic, Zambia and Tanzania, stretching through Lake Tanganyika). Forests would once have covered virtually the whole area, but now only 44 per cent of the watershed is forest, and deforestation is continuing at a rate of about seven per cent a year. Only about 5 per cent of the watershed is protected[209].

79. al-Iskandriyah (El Iskandriyah) (Alexandria), Egypt
Protected areas play no role in supplying the city with water
Much of the water comes from the Nile.

80. ad-Dar-al-Bayda (Casablanca), Morocco
Protected areas play no role in supplying the city with water
Most of the water comes from surface sources and there are currently problems in supply and pollution.

81. Kano, Nigeria
Protected areas play no role in supplying the city with water
Kano lies within the massive Niger watershed which encompasses ten countries and covers an area of over 2.5 million km^2. 96 per cent of the original forest cover has been lost and there are now no significant areas of forest left in the watershed. Only 5 per cent of the whole watershed is protected[210].

82. Ibadan, Nigeria
Protected areas are important for city's water supply
Part of Ibadan gets its water supply from the moist semi-deciduous forest of the Olokemeji Forest Reserve (7,100 ha) and Gambari Forest Reserve[211].

83. Abidjan, Côte d'Ivoire
Protected areas are important for city's water supply
Banco National Park (Category II, 3,000 ha) close to Abidjan serves as watershed to the rivers and dams providing drinking water to the city of Abidjan[212]. The Park, an area of dense rainforest traversed by the River Banco on the North bank of the Ebrié lagoon, is about 10km west of Abidjan in southern Côte d'Ivoire[213].

84. Cape Town, South Africa
Protected areas are important for city's water supply
Cape Town extracts significant water from catchment areas including the Cape Peninsula National Park (newly proclaimed see details below) and the Provincial Reserves along the Hottentots Holland (Hottentots Holland Nature Reserve Category IV, 24,569 ha) mountain range, in the Western Cape, most of which are managed as Mountain Catchment areas by the nature conservation agencies[214]. Cape Peninsula National Park (CPNP), which is almost entirely surrounded by the city of Cape Town, was proclaimed in 1998. The planned core area of the park will cover some 29,000 ha. Since proclamation the park has grown to nearly 22,100 ha, or about 73 per cent of the entire Cape Peninsula Protected Natural Environment (CPPNE). Of this, about 15,700 ha is proclaimed and some 6,400 ha is public land managed by the CPNP but not yet proclaimed. The predominant vegetation is mountain fynbos (fine bush), with other areas supporting a range of habitats from the rare renosterveld to evergreen forest. The Peninsula has more than 2,285 species of plants, of which 90 are considered endemic[215]. The Hottentots Holland Nature Reserve is also important for the conservation of mountain fynbos and has approximately 1,300 plant species, including several rare and endemic plants. Approximately 110 bird species have been recorded on the reserve, amongst them several species of raptor[216].

85. Addis Ababa, Ethiopia
Protected areas play no role in supplying the city with water
Water comes mainly from the Kechene and Akaki rivers.

86. al-Jizah (Giza), Egypt
Protected areas play no role in supplying the city with water
Much of the city's water is extracted from the Nile.

87. Nairobi, Kenya

Protected areas are important for city's water supply

Nairobi, the capital of Kenya, has a population of 3 million residents, which according to the U.N. Habitat (the United Nations Human Settlement Programme) is increasing at 5 per cent per annum[217]. Nairobi draws its water from several different sources, including the Ruiru, Sasumua, Chania II and Ndakaini systems[218]. The Sasumua dam, the second largest in the country, supplies two-thirds of the water to the Kabete reservoir in Nairobi's western suburbs, where it is then distributed to the city[219]. As the population grows, government figures predict that the country's per capita water supply will fall from the current 700m^3 to around 500m^3 by 2010. This shortfall is not helped by the fact that half of the water Nairobi imports daily, from between 125 and 370 miles away, is lost through leaks in the old pipelines and illegal connections[220]. According to the Water Resources Minister, Martha Karua, the future for ensuring sustainable water supplies to Nairobi and throughout Kenya, lies in harvesting rainwater, building reserves from dams, and replanting trees. This is, however, a long-term vision, which, as she states "will not produce results in an instant, but we want to look back five years, 10 years, 15 years later and say our forest cover now is 40 per cent — and this can be achieved"[221]. The main rivers emanating from the Aberdares (including the Aberdares National Park, IUCN Category II, 76,619 ha), and the Mt Kenya water catchment area supply Nairobi with drinking water. Much of the area is currently being logged, which may make the water supplies to Nairobi even more unreliable. According to a spokesperson from UNEP'S Global Resource Information Database: indigenous trees are important for the maintenance of water in streams as they capture mist from the atmosphere, and this mist contributes about 20 per cent of the water that flows from a forested area into a river[222].

88. Dar es Salaam, Tanzania, United Republic of

Protected areas are important for city's water supply

Dar es Salaam gets its water supply partly from the (southern) Ruvu River which arises in the Udzungwas (where there are forest reserves and Udzungwa Mountain National Park, Category II, 190,000 ha) and partly from the Selous Game Reserve (Category IV, 5,000,000 ha and World Heritage site)[223]. The Selous Game Reserve is the second largest in Africa and is part of the Selous ecosystem (7,400,000ha) which includes Mikumi National Park (Category II, 323,000 ha) and Kilombero Game Controlled Area (Category VI, 650,000 ha). The reserve was accepted as a World Heritage site in December 1982. A large area of the reserve is drained by the Rufiji River and tributaries which include the Luwegu, Kilombero, Great Ruaha, Luhombero and Mbarangardu (the only permanently flowing streams). There are two main vegetation types in the reserve: the eastern sector (17 per cent) is mainly wooded grassland dominated by *Terminalia spinosa* and the western sector (about 75 per cent) is deciduous miombo woodland with *Brachystegia*, *Julbernardia globiflora*, *Pterocarpus angolensis*, and *Combretum*. There are also areas of dense thicket, riverine and ground water forest. More than 2,000 plant species have been recorded, but it is thought that many more may be found in the remote forests in the south[224].

89. Durban, South Africa

Protected areas are important for city's water supply

Durban's water comes from a variety of sources, including the Drakensberg catchment areas (Ukhlahlamba-Drakensberg Park, Category I (48 per cent) and II (52 per cent), 242,813 ha, World Heritage Site, RAMSAR site) as well as protected areas such as the Umgeni Vlei. The Drakensberg is regarded as the most important mountain catchment in South Africa because of the high water yield and good quality water which flows from it[225]. The harvesting of this major resource is through a series of large dams set in the upper catchments of the province's major rivers such as the Thugela, the Bushmans and the Umgeni. The Umgeni River has several dams which supply water to Durban (Midmar Dam, Inanda Dam, Albert Falls Dam), which are proclaimed nature reserves and are managed by KZN Wildlife[226]. The Drakensberg is an island mountain range in the KwaZulu-Natal Province, along the south-western border with Lesotho. The World Heritage site is composed of four

different designations: State Forest (6 sites), Game Reserve (1), Nature Reserve (4 sites) and National Park (1 site). The various protected areas that collectively constitute the nomination site were separately established, between 1916 and 1967. The Drakensberg is one of the least drought-prone areas of southern Africa. The vegetation forms three main topographical features: the low altitude belt (1280-1830m) with *Podocarpus* forest, the mid altitude belt (1830-2865m) with *Themeda* grasslands and *Passerina-Phillipia-Widdringtonia* thickets and the high altitude belt (2865-3500m) or alpine tundra with *Erica-Helichrysum* heath[227].

90. Dakar, Senegal

Protected areas play no role in supplying the city with water

A substantial proportion of Dakar's water is sourced 200 km from the city from Lac de Guiers in the Lower Senegal River Basin, as local sources of groundwater have been over exploited and polluted and aquifers over-pumped, resulting in increased salinity[228]. Ecological changes, particularly physical and chemical changes in the water environment, have resulted from the construction of dams (Diama and Manantali) in the river basin. Overall, the basin ecosystems and production systems are now threatened by decreasing productivity due to inadequate resource management, including deforestation, soil erosion, overgrazing and desertification. Species diversity has been reduced, along with elimination of wetlands by diking and expansion of irrigated areas. The watershed of the Senegal River covers over 400,000 km^2 has been completely deforested. Six per cent of the watershed is protected[229].

91. Luanda, Angola

Protected areas play no role in supplying the city with water

The Dutch introduced a water supply and sanitation to the city in the mid-17th century by building a canal from the Kwanza River to the south of the city. In 1889, water from the northern Bengo River was added to the system via aqueduct. Though the two rivers still supply Luanda, the city's existing 600km distribution network has failed to match rapid population expansion[230].

92. Tarabulus (Tripoli), Libya

Protected areas play no role in supplying the city with water

Tripoli is increasingly reliant on groundwater from the central Sahara desert, through a massive pipeline project called the Great Man Made River. Groundwater sources are currently being tapped faster than they are renewed, causing political tensions.

93. Harare, Zimbabwe

Protected areas are important for city's water supply

Harare draws its water from two lakes: Lake Chivero – formerly Lake MacIlwaine (within the Robert McIlwaine Recreational Park, Category V, 55,000 ha including 30,000ha water) which is contiguous with Lake Darwendale (within the Lake Robertson Recreational Park (Category V, 8,100 ha), both of which are under the Parks and Wildlife Act[231]. The 14.5km long Lake Chivero was created by a dam across the Hunyani River, and forms the main supply of water to Harare. The vegetation in the Robert McIlwaine Recreational Park is typical Mashonaland highveld, which is retained in its natural state in certain parts of the park and does not occur in other conservation areas in Zimbabwe[232].

94. Al-Jazia'ir (Algiers), Algeria

Protected areas play no role in supplying the city with water

95. Johannesburg, South Africa

Protected areas are important for city's water supply

Johannesburg derives a good deal of its water from the Maluti/Drakensberg Transfrontier Park – created in 2001 (which is also a nominated World Heritage Site). Water is sourced either (i) via the Tugela / Vaal transbasin pumped storage scheme, the water coming from the Ukhahlamba-

Drakensberg Park (see Durban entry), including some parts of the mountains, such as the Mnweni area, which are not protected areas; or (ii) the recently established Lesotho Highland Water Scheme (the source is the highland wetlands) which are traditionally protected e.g. the Phofung area (Mont-aux Sources) and the Senqu sources. Some small areas of the catchment are being incorporated into protected areas (Ts'ehlanyane, Bokong Nature Reserves). Although the scheme is not situated in the core area of a conservation site, the water drains from the catchments of the Maluti/Drakensberg Transfrontier Park on the Lesotho side. South Africa is one of the first countries in the world to adopt a National Water Act that incorporates a Catchment Management Strategy for sound water resource management. Johannesburg is one of the first cities in the country to develop catchment management strategies at a local level for two rivers flowing through town. Johannesburg receives water from the Vaal River and the Lesotho Scheme. Following current demand projections Johannesburg's water resources will be exhausted by 2020. The city is thus placing great emphasis on water conservation and demand management[233].

96. Khartoum/Omdurman, Sudan
Protected areas play no role in supplying the city with water
The Khartoum area is a part of Khartoum basin that is situated at the northern periphery of the Blue Nile rift basin[234]. Khartoum gets its water from either the Nile at the confluence or upstream from the White Nile at the Jebel Aulia Dam - in the watershed of the White Nile[235]. In total, 45 per cent of water supplies for the Khartoum area come from direct pumping from the two Niles[236].

97. Ar-Ribat (Rabat), Morocco
Protected areas play no role in supplying the city with water
Most of the water comes from surface sources and there are currently problems in supply and pollution.

98. Conakry, Guinea
Protected areas play no role in supplying the city with water
Much of the water comes from surface sources collected in the Grande Chutes reservoir, although there are major problems with distribution and supply[237].

99. Accra, Ghana
Protected areas play no role in supplying the city with water
Accra's main water supplies are piped from a coastal stream, the Densu. Water shortages, leading to power shortages, are due to substantial increases in population, and drought conditions[238].

100. Kaduna, Nigeria
Protected areas play no role in supplying the city with water

Australia/Oceania

101. Sydney, Australia
Protected areas are important for city's water supply

The Sydney Catchment Authority was established in July 1999 to manage and protect Sydney's catchments and to provide a bulk raw water supply to its customers; including Sydney Water which delivers around 1,600 million litres of water a day to more than four million people in Sydney and the surrounding areas. The catchments cover almost 16,000km^2, extending from the upper Blue Mountains, south to the source of the Shoalhaven River near Cooma, and from Woronora in the east to the source of the Wollondilly River near Crookwell. Although this area represents only about two per cent of New South Wales, the catchments supply water to over 60 per cent of the states population.

Around 25 per cent of the water supply catchments are known as 'Special Areas'. Special Areas are mostly of prinstine bushland close to the reservoirs or dams. Most Special Areas represent only a part of the entire catchment, acting as a buffer zone to stop nutrients and other substances that could affect the quality of water entering the water storage areas. The Sydney Catchment Authority and the National Parks and Wildlife Service jointly manage the Special Areas, in accordance with the Special Areas Strategic Plan of Management. The Blue Mountains National Park (Category II, 247,021 ha) is important as a major water catchment area for Sydney. Most of the southern section of the park, together with parts of the adjoining Kanangra-Boyd National Park (Category Ib, 65,280 ha), is included in the Warragamba Special Area and has an important function in contributing water to Lake Burragorang, Sydney's major potable water source. The park's vegetation is comprised of about 40 distinct communities, many of which are restricted in occurrence or unique to the Blue Mountains area. Most are dry forests (45 per cent of the park) and woodlands (38 per cent) dominated by eucalypts, with the remainder being 'rocky complex' heaths (10 per cent), 'plateau complex' heaths and low woodlands (3 per cent) and moist forests and rainforests (2 per cent). Blue Mountains National Park, together with Kanangra-Boyd, Wollemi, Gardens of Stone, Nattai, Thirlmere Lakes and Yengo National Parks and Jenolan Karst Conservation Reserve, is inscribed on the World Heritage List as the Greater Blue Mountains World Heritage Area. Other reserves within the catchment include the Dharawal Nature Reserve (Category Ia, 341 ha) and Dharawal State Recreation Area (5,650 ha)[239].

102. Melbourne, Australia (see case study)

Protected areas are important for city's water supply

Ninety per cent of Melbourne's water supply comes from uninhabited mountainous catchments to the north and east of the city. Mountain Ash (*Eucalyptus regnans*) produces approximately 80 per cent of Melbourne's water, and nearly 50 per cent of the catchments are in protected areas. Melbourne Water manages some catchments just for water collection, and works closely with the Department of Sustainability and Environment and Parks Victoria in managing catchments in state forests and the Kinglake (Category II, 21,600 ha), Yarra Ranges (Category II, 76,000 ha) and Baw Baw (Category II, 13,300 ha) National Parks[240]. Melbourne has been recognised as having the highest quality drinking water of any Australian city.

103. Brisbane, Australia

Protected areas play a minor role in the city's water supply

The water supply for Brisbane originally came from the protected forested catchment of Enogerra Creek. The Enoggera Reservoir was constructed in 1866 and provided the first reticulated water supply for Brisbane. The Gold Creek Reservoir was constructed in 1886 and served as a stand-by supply for Enoggera Reservoir. These two reservoirs were connected by an underground tunnel constructed in 1928. The third reservoir in Brisbane Forest Park is Lake Manchester. It was built in 1916 to provide emergency supply for the Mount Crosby treatment plant (which is on the Brisbane River) in times of high consumer demand or low river levels. Today, these three reservoirs are all managed for water catchment protection and cultural heritage values. D'Aguilar National Park (2,050 ha, Category II) covers five per cent of the Forest Park, and is managed Environmental Protection Agency, Queensland Parks and Wildlife Service. D'Aguilar National Park is managed over six areas, which include Maiala, Manorina, Boombana, Jolly's Lookout, Cabbage Tree Range and Kipper Creek. The vegetation types represented in these areas include wet and dry sclerophyll forests and rainforest[241]. They form part of the multipurpose Brisbane Forest park which covers 28,500 ha and stretches over 70km along the Taylor and D'Aguilar Ranges

The Brisbane Forest Park Authority was established in 1977, creating Queensland's first coordinated conservation area ('coordinated' because so many state and local authorities had responsibilities within the area). Today, the Brisbane Forest Park is an administrative construct involving an amalgam of National Park and State Forest, however currently State Forests are being transferred to National Park

status[242]. The Authority manages in co-operation with three different land managers. State Forests comprise the largest section of land area in the Park (70 per cent) and are managed by the Department of Natural Resources, Forest Resources. Brisbane City Council manages 25 per cent of the land area, including the three reservoirs in the Park, Gold Creek, Enoggera and Lake Manchester, as well as some of the recreational areas.

While catchment management is still an important priority within the Park, the bulk of the cities water now comes from rural watershed further away from the city that supply three water main storages – Wivenhoe Dam, Somerset Dam and North Pine Dam[243]. Lake Wivenhoe is situated on the Brisbane River approximately 150km from the river mouth and commands around 40 per cent of the total catchment of the river. The dam was completed in 1985 and provides water supply and flood mitigation. Somerset Dam is situated on the Stanley River, approximately 220 km upstream from the mouth of the Brisbane River. Water is released from Somerset Dam to supplement Wivenhoe Dam, which in turn supplements the natural flow of the Brisbane River and maintains an adequate supply of water to the Mt Crosby pumping station, 132 kms downstream from Somerset Dam. The Mt Crosby treatment plant purifies the river water which is then piped to the cities of Brisbane, Logan, Ipswich and Redcliffe[244]. Approximately one third of the catchment areas of these storages is still under natural vegetation but only a small percentage is formally reserved as National Parks or State Forests. The most common land use in the catchment is cattle grazing.

104: Perth, Australia

Protected areas are important for city's water supply

A continuing period of climate variability affecting the south west of Western Australia has seen a 12 per cent decrease in rainfall reduce streamflow to Perth's water supply reservoirs by 50 per cent during the last 27 years[245]. About 70 per cent of Perth's mains water comes from reservoirs, the rest is pumped from underground. The Darling Ranges, large areas of which are covered with eucalypt forests, form the catchment for Perth's water supply, and contain 11 dams and reservoirs. The Yanchep National Park (Category Ia, 2,842 ha) lies towards the edge of the Gnangara Mound, an extensive unconfined ground water aquifer that provides approximately 20 percent of the public water supply for Perth. The Mound is recharged by the direct infiltration of rainfall, mostly between April and October. There are conflicts over the water resources within the Park with the Water Authority considering that the environmental impact on the Park of ground water abstraction is low, whilst the Environmental Protection Authority consider the impact on two of the parks main lakes, Loch McNess and Yonderup Lake, unacceptable[246].

105: Adelaide, Australia

Protected areas play no direct role in supplying the city with water, some of the watershed is protected

Adelaide's drinking water comes from two main sources; the Murray River and the catchments that form the Mount Lofty Ranges. Unlike the water supply catchments of most other Australian capital cities the catchments of the Mt Lofty Ranges are used for many different purposes including harvesting of drinking water, agriculture, intensive horticulture, recreation, rural living, tourism, environmental conservation and urban environments. Over time, these multiple uses have led to fundamental landuse conflicts that have placed pressure on the water resource and have resulted in a number of water quality issues, such as blooms of toxic algae in dams and reservoirs, stock deaths due to drinking water contaminated by toxic algae, pesticides causing contamination of some rivers and streams, water-bourne parasites, *Cryptosporidium* and *Giardia*, detected in rivers and streams, sediment from erosion of degraded river banks, overgrazing and intensive horticultural practices deposited in streams and localised heavy metal contamination. Large storage reservoirs have been constructed on some of the numerous rivers and streams of the Mt Lofty Ranges to harvest rainfall and supply Adelaide with drinking water. The Mt Lofty Ranges Watershed has a low 'water yield to catchment area' ratio due to the relatively low intensity rainfall and annual average rainfall, high number of farm dams and high

rates of evaporation, therefore there has been a need to supplement drinking water with water from the River Murray. Analysis of the volumes of water which have been supplied greater Adelaide mains water consumers, over a 21 year period to 2002, from natural intakes to reservoirs in the Watershed compared with volumes pumped from the River Murray to supplement water supply requirements, shows there has been a very wide variation in the proportions of natural runoff intake versus supplementary pumping from the River Murray from one year to the next. However, over the 21year period the natural runoff from the Watershed has supplied 64 per cent of Adelaide's water supply.

The Mt Lofty Ranges catchments cover 4,000 km^2. Within this area there are seven reservoirs, the largest of which is Mount Bold, capable of storing 45,900 megalitres of water. Annual Adelaide metro consumption of mains water is 300,000,000 m^3. There is less than 13 per cent of native vegetation remaining in the Mount Lofty Ranges and of this vegetation, less than 20 per cent is formally protected in the following forms:

- National Parks and Wildlife Act 1972 – Conservation Parks, National Parks and Recreational Reserves
- Crown Lands Act – Conservation Reserves
- Forestry Act – Native Forest Reserves
- Native Vegetation Act – Heritage Agreements (privately owned land)

The National Parks and Wildlife South Australia (NPWSA) reserves in the Mt Lofty Ranges Watershed protect less than 15,000 ha of native vegetation. Forestry South Australia (SA) also own and manage less than 5 per cent of native forest that would contribute to water quality. However all these government owned areas are small in comparison to the amount of privately owned native vegetation within the watershed. A further seven per cent of native vegetation is owned and managed by SA Water, however this is not 'formally' protected for the conservation of biodiversity (whilst SA Water land is managed primarily for water quality it is also managed with the understanding that water quality is ultimately linked to native vegetation, and because there is a no public access policy much of this land is in better condition than many of the NPWSA reserves in the region). The situation in the Mt Lofty Ranges is thus as follows:

- Most of the 'protected areas' (e.g. NPWSA reserves) are at the very edge of the Watershed boundary meaning the water exiting these land uses is lost as storm water via a metropolitan drainage system.
- Where protected areas occur within the Watershed, they are small and the water quality service they provide may be almost insignificant in relation to the area of native vegetation privately owned in the same area.
- The SA Water reservoir reserves generally contain a high level of native vegetation but only in the land immediately surrounding the reservoir. They also contain pine plantations (linked to raised dissolved oxygen levels in water), grazing land (*Cryptospyridium* and *Giardia*) and hay fields).

Over 12 years the former Engineering and Water Supply Department (now SA Water) conducted a major water quality monitoring programme which looked at the fundamental differences in water quality derived from different land uses in the Mt Lofty Ranges Watershed. The report prepared at the completion of this study identified major differences in the load of water pollutants derived from each of the dominant land uses. The pollutant loads derived from the native vegetation sub-catchment was lowest in all respects. This water quality monitoring programme clearly showed that native vegetation is by far the most preferred land use in the Mt Lofty Ranges Watershed from a water quality perspective, and that there are substantial differences in the water pollutant loads derived from a range of other land uses. Flow proportional composite water quality sampling conducted by the State Government during the 1994 to 2002 period showed similar fundamental differences in water pollutant loads derived from subcatchments dominated by different landuses in the watershed[247].

Part 3: A wider perspective on water and protection

Hydrology overview by Larry S Hamilton[‡] and David Cassells[§]

Forests protecting the water spigots? Or thirsty trees using our water supplies?

Severe water shortages already occur in several parts of the world and this situation is worsening each year. Freshwater withdrawals increase with increasing population and increasing per capita needs and wants, and both ground water aquifers and low-season streamflows are experiencing depletion. This is being acerbated by the current alarming rate of mountain glacier retreat, for glaciers and winter snow accumulation in mountain areas nourish many of the world's rivers[248]. While this water use crisis will adversely affect water supplies for irrigation agriculture, farm animals, hydropower, navigation, in-stream fisheries and drinking supply for terrestrial and avian fauna, the most serious deficit crunch will be for potable water for humans in our cities, villages and rural areas. This derives from the need for water of sufficient *quality*, and at a reasonable price. Access to potable water is increasingly being recognized as a basic "human right", and this includes a reasonable price[249]. The minor revolution in Cochabamba, Bolivia in 2000, in which "water warriors" protested, struck and blockaded against the government over the management of the City's water utility by a private company is indicative of the increasing tension and conflict over water[250].

All plants intercept and re-evaporate precipitation, as well as transpire very large amounts of water from soil moisture. Trees and forests, with their deep root systems are particularly heavy users of water[251]. With this water however, they become photosynthetic "factories" churning out a host of useful and wonderful products and services. These range from conversion of carbon dioxide to oxygen, to construction material for shelter, to Brazil nuts, to tree frogs, tapirs, koalas and scarlet macaws. However, they do not do this "free of charge" and these various products and services are dependant on the forest's use of a significant share of the planet's water. However, forests, more than most other cover on the landscape, maintain the quality of the water they receive and that flows through them. Wetlands are probably equally good. Grasslands are usually grazed, and thus more prone to lose some water quality protection value.

Overview

Mountains receive the bulk of the earth's precipitation[252].Mountain forests, which are in the headwaters therefore of the land's water distribution channels, have a major influence on the quantity and quality of this precious freshwater resource. There are some special kinds of forests, montane "cloud" or "fog" forests, which have relatively low water use due to the frequency of a high humidity or wet envelope, and which actually rake moisture out of clouds or fog, and add it to the water supply of a catchment[253].This water extraction function is lost if cloud forests are removed, because it is an addition to vertical precipitation. Forests also are usually the very best cover for safeguarding water quality from the deleterious impacts of sediment and non-point source chemicals. Pollution from these substances can make water unfit for human (and other animal) use, or incur major costs for removal from the water supply. In addition, forest cover can reduce the problem of flooding from many small, frequent storm events in headwater watersheds close to the forest area in question[254]. In the remainder of this chapter, we will deal with each of these functions in more detail, to get a clearer picture of the role of forests in watersheds or catchments, and present some examples which help us to appreciate the value of forests with respect to water.

[‡] Consultant, World Commission on Protected Areas Vice Chair for Mountains
[§] Senior Forest Advisor, The World Bank

Erosion and sediment

The undisturbed forest with its understory, leaf litter and organically enriched soil is the best watershed land cover for minimizing erosion by water[255]. Surface erosion (which includes sheet and rill erosion types) is minimal due to this understory and leaf litter, which protect the soil from raindrop impact particle dislodging, promotes maximum infiltration of water into the soil and slows downslope water movement by myriad barriers of leaves, twigs and debris. Any activity such as litter collection, fire, grazing or scraping in logging, that removes or significantly reduces this protection increases erosion. Even more serious, mass soil movements due to shallow landslips that are triggered in saturated soils in slip-prone locations, are also minimized by forests. In this case, it is the anchoring function of tree roots that provides an extra margin of shear strength to the soil mass[256]. Removal of the forest by land clearing, or even the temporary removal of most trees in logging increases the risk of landslips.

A dramatic example of landslip catastrophe occurred in southern Thailand in 1988 when thousands of landslips occurred in lands cleared for rubber plantations and farms[257]. This sent huge amounts of sediment into rivers already swollen by heavy rainfall of between 450 and 1000 mm in two days. The sediment-choked rivers and streams flooded massively. Loss of life exceeded 300; 4000 homes were lost and another 4000 partially destroyed along with 300 bridges and agricultural damage. Strangely, the catastrophe was blamed on logging, rather than forest clearing, and Thailand instituted a logging ban rather than tightening the conditions for forest conversion[258]. A similar kind of event occurred during Hurricane Bola in New Zealand in that same year. Thousands of shallow landslips developed over large landscapes in North Island in once-forested pasture lands, along with some major deep-seated slope failures[259]. Where forests older than 5 years occurred, the incidence of landslips was only one percent of the area, versus 30 percent for the cleared lands.

In minimizing surface erosion and mass movements, forests reduce the problem of sedimentation: the carrying or deposition of soil particles in water courses. Suspended soil in water supplies can render potable or irrigation water unfit for use, or greatly increase costs to make it useful. In addition sediment can reduce river channel capacity, kill or harm fish and other aquatic life, interfere with navigation, reduce reservoir capacity prematurely, and increase wear on hydroelectric turbines. Keeping soil in place on the land makes good ecological and economic sense, and forests do this better than most other kinds of land cover or land use (short of concreting it over).

Other contaminants

Most land uses that replace forests have a greater likelihood of impairing water quality through the addition of "pollutants" to the watershed. Excess fertilizer on agricultural or grazing lands, pesticides applied to horticultural or agricultural crops or to lawns find their way into ground water aquifers or surface streams and rivers. Animal manure is another source of possible over-enrichment or contamination. In areas of the world where salt accumulates in the subsoil, forest removal results in the groundwater levels rising closer to the surface (due to decreased evapo-transpiration) which may bring the salt into the root zone for plants. Surface salinization has rendered thousands of hectares of former forest in Australia, now cropland, unsuited to further cropping, except for very salt-tolerant plants[260]. Moreover, lateral movement of salts in groundwater recharge of streams, can render these surface watercourses unfit for irrigation or domestic water. In Western Australian, large-scale reforestation programs to lower groundwater levels, are attempting to repair the situation. Retaining protected forests in salinity-prone areas would be a better policy.

The search for water quality

When quality water is needed, forests are usually the safest cover or land use. As noted above undisturbed forest cover usually provides the best protection against erosion, sedimentation and the

transport of other contaminants. These benefits do, however, depend very much on management - forest disturbance or even poorly planned or constructed roads and recreational infrastructure can significantly reduce the forest's protective function. In addition, deposition of most atmospheric pollutants to forests is higher because of the differences in aerodynamic resistance of forest canopies and shorter crops and, as a result, forest catchments may be more susceptible to long-term acidification of catchment soils and runoff in high pollution industrial climates[261]. This is especially true at high elevations and high latitudes due to the phenomenon of "cold condensation" of persistent organic pesticides.

The overall superiority of forests as a protective catchment cover has led to the establishment of protected watershed forests where a water supply source of potable water is needed. Good examples come from Melbourne in Australia and New York City (see case studies). Quito, Ecuador is undertaking a water supply charge which will be transferred to the two protected mountain watersheds of the Pita and Cinto Rivers in the Antisana and Coyambe Reserves[262].In the United States, 354 protected (roadless) areas of National Forest are source areas that provide water for drinking to communities, including the cities of Santa Fe, Portland and Seattle[263]. Much of the water in Harare, Zimbabwe and Freetown, Sierra Leone comes from forest protected areas[264]. Communities all around the world have sought water supplies that are free of suspended sediment and harmful chemical elements or compounds. They find these mostly in forest areas which do not have intensive use by machinery, humans or domestic animals, and especially find them in *forest protected areas*, where such uses are controlled or are minimal.

Floods and protected forests

There is still a fairly widespread but erroneous belief that forest-covered upper watersheds will *prevent* floods on the mainstem, downstream reaches of major rivers[265]. Forests are still visualized by many as behaving like a sponge, whose roots "suck up" water in times of excess (a storm event) and then release it gradually during the post-storm or post-monsoon season to augment dry-season flow. Unfortunately tree roots are more like a pump than a sponge[266]. Cutting the forest therefore usually increases the dry-season flow, but it also somewhat increases flood flows. The water storage on a piece of upland landscape is in the soil, and the amount that can be stored to reduce flooding from single storm events depends on the soil depth, its infiltration capacity (lack of compaction), texture, structure and degree of previous saturation with water. Forests influence some of these characteristics, -- antecedent soil moisture, infiltration capacity and structure, and are usually the hydrological best bet for reducing storm flow volumes, lowering peak flows and delaying peaks, in watercourses emanating from the watershed[267]. However, this flood reduction effect occurs only in the frequent, lower intensity, short-duration storm events, and becomes overridden in prolonged in prolonged, high intensity events or monsoons. Also, the effect may be significant in small watersheds, with deep soils, but diminishes as the watershed size increases to river catchments and river basins[268]. This happens because different land uses come into play, differences in geology and soil depth, direction of storm path across or along the basin, human constriction of channels and so forth. Catastrophic floods of the lower basin flood plains of major rivers cannot be blamed on lack of forest cover in the mountain headwaters, as has been so often claimed in the Ganges and Brahmaputra and others[269].

However, many people live in upland watersheds, and damage to their fields and homes, washout of roads and bridges, contamination of their water from flood runoff are major problems. Protected forested watersheds do have a beneficial effect to local communities or settlements close to the area in question. They are hydrologically the safest land cover and land use that exists, especially if any roads are well located, well designed and well maintained. If wood harvesting or non timber forest product harvesting is carefully done, adverse effects can be minimized. A truly protected, but "used" or

"inhabited", forest would have such environmental safeguards (a Category V or VI in the IUCN system), and would therefore minimise the risk of close-to-source flooding events and severity.

The role of swamp forests in storing water and delaying its march to the lowlands and to the seas, also must not be ignored. The amazing flooded varzea forests of the Amazon are a remarkable example of the value of wet forests to river basin ecosystems[270]. But swamps in the uplands also have a water "balancing" function which often merits protected forest status (as well as the other biological values of wetlands).

Montane cloud forests

Cloud forest are the vegetation type where the interests of biodiversity conservation and watershed protection converge most clearly. Cloud forests not only provide the protective benefits previously discussed, but can also introduce additional water into the system above that received by vertical precipitation. These biologically rich mountain forests with their abundant mosses, lichens and other epiphytes capture water from horizontally moving cloud or fog on their myriad vegetative surfaces, especially where consistent winds drive these atmospheric moisture systems through the forest. Since water uptake from the soil by trees whose foliage is wetted is strongly reduced, overall water use by cloud forests is typically much lower than that of forests lower on the mountains. These two sources of gain in water yield means that stream-flow emanating from cloud forest areas tends to be larger for the same amount of rainfall, and is also more dependable during dry periods. The extra water is particularly marked, and particularly important in places with low rainfall but where a low cloud deck touches the mountains[271]. Here, water gains from cloud forest can be 100 percent or more greater than from ordinary rainfall. In humid areas, it may be only 15-20 percent greater, but even this addition can be significant to communities that are experiencing shortages of quality water.

These cloud forest belts or zones typically occur at elevations of 2000-3500 m on large continental interior mountains or mountain ranges, but on island mountains may occur as low as 400-500 m above sea level[272]. If they are totally removed, this water capture function of cloud "stripping" is lost. Very often the soils under these forests is not adaptable to other sustainable use, yet they are being cleared and converted to grazing or temperate crop production in the tropics, and being heavily harvested for fuelwood and charcoal. They are also being adversely impacted by global climate change (changes in occurrence of the cloud deck) and by cloud-borne air pollution.

While all water supply watershed forests merit protection status, montane cloud forests in the watersheds deserve special consideration as protected areas, to be minimally disturbed.

Protected streamside riparian zones

Also of high priority for tight protection within the watersheds are the forested (or other natural vegetated) strips of land along the streams in question. These riparian zones are probably the most critical of all needing protection in a water supply catchment[273]. This is especially true if there are non-forest land uses beyond the riparian zone which are a source of sediment, fertilizer, pesticides or other water contaminants. Intact forests along streams at least 20-30 m in width (wider if the land is steeply sloping) can filter and immobilize sediment and these compounds, reducing water pollution. They can only trap sheet and rill erosion from upslope, for channelised sediment, as in landslides, will break through most normal-width buffers. Riparian forests also reduce streambank erosion. They keep streams cooler. When these water-related values are added to their great value in providing terrestrial and avian fauna habitat and safe access to water, rich riparian plant habitat, and healthier stream habitat for fishes and other aquatic life, the critical nature of these zones becomes apparent[274][275]. Since they

form the vital link between watershed lands and stream systems, they merit protected status as areas of great significance.

Protected mangrove forests along tidally influenced streams and rivers also perform many of these functions. In trapping and immobilizing sediment and toxins like heavy metals, in their muds they promote a healthy near-shore fishery and coral reef system[276]. They have too often been cleared as "wastelands" and converted to non-sustainable rice production or aquaculture ponds. They merit protected status in very many situations.

Dawning recognition of watersheds

At long last, urbanites and their politicians seem to be realizing that in most cases the water coming from the urban taps originates in rural or wild watersheds. Back in 1984, Director of National Parks in Venezuela, José Rafael García referred to Guatopo National Park (headwaters for water supply to Caracas) stating: "the most important thing is that the water from this park is of very high quality, and for this reason its treatment for human consumption is less expensive.[277]. Spectacular rainforests and high quality watershed only two hours from Caracas! Moreover, awareness is dawning that protection of the watershed supply area costs money, and water consumers will have to pay a reasonable amount for this. The water-payment scheme for Quito's protected watersheds has been briefly mentioned. In Honduras, an association of 16 municipalities near Lake Yojoa are engaging in an annual environmental service payment scheme through conservation easements on key watershed lands. "Payments for environmental services" involving forests and hydrologic benefits are also now in effect in Costa Rica, Mexico, El Salvador, Colombia, and Brazil[278]. This seems to be the wave of the future and a timely one as the water crunch spreads. However, in putting a price on watershed protection, we need to ensure that the rights of the poor to equitable and affordable access are not ignored[279]. Protected watershed forests have a major role to play in attending to this basic human need.

Economics overview by Stefano Pagiola**

Paying for watershed services

Tropical forests provide a wide variety of valuable services, ranging from the regulation of hydrological flows to biodiversity conservation and carbon sequestration. Nevertheless, an average of almost 15 million hectares of forest was lost every year during the 1990s, mostly in the tropics[280]. An important reason for this loss is that those who manage tropical forests typically receive no compensation for the services that forests generate for others. As a result, they have little incentive to conserve them.

Recognition of this problem and of the failure of past approaches to dealing with it has led to efforts to develop systems in which land users are paid for the environmental services they generate, thus aligning their incentives with those of society as a whole[281]. The central principles of the "payment for environmental services" (PES) approach are that those who provide environmental services should be compensated for doing so and that those who receive the services should pay for their provision. This approach has the further advantage of providing additional income sources for poor land users, helping to improve their livelihoods.

Although the approach is intuitively appealing, putting it into practice is far from simple. Making market-based mechanisms work for both forests and people is not easy. Designing and implementing the necessary rules and institutions is a daunting task under the best conditions. A large number of building blocks need to be in place, including a strong understanding of the underlying relationship between land use and service generation, an economic analysis of the benefits these services provide to users and of the cost to land users of providing them, and the creation or strengthening of the institutions required. Moreover, the precise details of the implementation of PES programmes can vary substantially from case to case, depending on the ecological, socio-economic, and institutional context.

Most PES programmes are still too new for a definitive assessment of their success and for detailed guidelines for their implementation to be developed. Nevertheless, considerable experience has been accumulated, and some initial lessons are discernible.

The logic of payment for environmental services

Land users often receive few benefits from forest conservation. In many cases, these benefits are less than the benefits they would receive from alternative land uses, such as conversion to pasture. But deforestation can impose costs on downstream populations, who no longer receive the benefits of ecological services such as water filtration. A payment by the downstream beneficiaries can help make conservation the more attractive option for land users. The payment must obviously be more than the additional benefit to land users of the alternative land use (or they would not change their behaviour) and less than the value of the benefit to downstream populations (or they would not be willing to pay for it)[282]. It is important to note that this logic remains in place year after year—payments must be made every year that service provision is desired, and not only on a one-time basis.

PES programmes promise to be more efficient than traditional command-and-control approaches. The costs of achieving any given environmental objective are rarely constant across all situations and

** This essay draws on on-going work on payments for environmental services at the World Bank. Portions of it have appeared previously, in sections of the book *Selling Environmental Services*, edited by Stefano Pagiola, Joshua Bishop and Natasha Landell-Mills (Earthscan, 2002) and in a paper presented to the spring 2003 meeting of the Society of Tropical Foresters, held at Yale University, which was co-written with Gunars Platais, also of the World Bank.

instruments such as PES can concentrate effort where costs are lower. Likewise, the benefits of conservation can differ substantially from case to case.

The value of environmental services to watersheds

Forests can provide a wide variety of services. The main services of interest are usually ***hydrological benefits***, including controlling the timing and volume of water flows and protecting water quality, reducing sedimentation, and preventing floods and landslides; ***biodiversity conservation***; ***carbon sequestration***; and, in some cases also ***scenic beauty***. These are for instance the four services named in Costa Rica's 1996 Forestry Law, which launched the country's PES programme. Here we concentrate on the first of these. For many developing countries, water services are of primary concern, as they have important national impacts.

For a PES programme to be developed, detailed information is needed on *which* services a given forest is providing, and to whom. Yet much less is known about the environmental services generated by different kinds of land uses than is often thought, particularly in terms of quantitative data.

Markets for watershed protection generally do not involve directly trading water quantity or quality. Rather, they usually involve 'selling' land uses that are thought to generate the desired water services. While forests are widely believed to provide a variety of hydrological services, the evidence is often far from clear (see accompanying essay by Hamilton and discussion in the main text). This is partly a reflection of the diversity of conditions encountered – variations in rainfall regime, soil type and topography all affect service provision. Deforestation can have multiple, sometimes contradictory impacts, making the net impact on water services hard to determine.

Water-related services provided by a given forest also depend on the number and nature of downstream users. Reducing sedimentation, for example, will be of limited value if there is little or no infrastructure vulnerable to sediment downstream of a forest. Likewise, reducing flood risk will be more valuable the greater the number of people and the value of assets at risk. The precise nature of services sought by downstream users also varies tremendously. Domestic water supply systems require a constant flow and high quality, but hydroelectric power producers with reservoirs usually prize total volume and care little about water quality except for the absence of sedimentation. Riparian communities are particularly concerned to avoid high peak flows that could flood their homes and fields. Depending on the mix, number, and relative importance of downstream uses, different types of water services will be particularly important in each case, with implications for the preferred upstream land uses. Where dry season water flows are of primary importance, land uses with high infiltration and low evapotranspiration would be preferred. Conversely, where minimizing the risk of flooding is the primary objective, land uses that maximize both infiltration and evapotranspiration would be preferred.

Unfortunately, most PES programmes developed to date have paid insufficient attention to the need to understand forest-hydrology linkages in detail. Costa Rica's PSA programme, for example, simply relies on the conventional wisdom that forest cover is beneficial for forest services[283]. More recent efforts in other countries have placed a greater emphasis on this topic, but are encountering significant constraints due to the lack of data.

Beyond the need to ascertain the linkage between forests and water flows, efforts to develop markets for water services face several particular challenges. First, water flows downhill, usually restricting access (and so, potential sales) to users within a watershed. The Río Nizao watershed in the Dominican Republic offers substantial potential for the use of PES, for example, as its four dams provide a substantial part of Santo Domingo's water supply, a major portion of the country's HEP generating

capacity, and water to two major irrigation systems. By contrast, the adjacent Río Ocoa provides almost no water services, despite being almost identical ecologically and hydrologically, as there are no significant downstream users. Second, use of water flowing in a river, or in an underground aquifer, cannot easily be confined to those who paid to protect that flow. Hence non-payers ('free riders') may benefit from the expenditure of others, undermining the incentive to pay, particularly where there are many beneficiaries. There may also be problems of coordination among different types of users. Against these limitations, water markets have the advantage that services are well-defined and often of high value.

Financing compensation for environmental services

PES programmes involve three distinct financing needs. First the up-front costs of establishing the system itself, including the costs of clarifying technical factors (for example, understanding hydrological linkages), of establishing appropriate organisations, and of ensuring that a supportive legal framework is in place. Second, the need to make the payments under the system; this is clearly the largest single item. Third, the on-going running costs of the system must be paid, including the costs of administration and monitoring. (It should be noted that some of the transaction costs are pushed onto participants. Participants in Costa Rica's PSA programme, for example, need to develop management plans, at their own cost. Although these costs do not appear as a financial cost to the PES system, they are a social cost and need to be addressed.)

The up-front costs of creating a PES programme pose particular problems as they must be borne before it begins generating funds. Assistance from outside agencies is often invaluable, particularly when some of the costs involve research into environmental services, which is often beyond the capability of local agencies. (Once the PES scheme is in place, these costs can be repaid by a levy on payments.)

Financing the payments to service providers and the transaction costs of the system requires establishing secure, long-term sources of financing. As noted above, payments under a PES scheme usually have to be long term and open ended. The first step entails identifying not only the beneficiaries but also the specific services they receive, because the willingness of a given group of beneficiaries to pay depends on the specific service they receive, on the value of that service to them (compared with the cost of alternatives), and on the size of the group.

Water benefits are easiest to capture when users are already organised (as in the case of municipal water supply, irrigation systems, and HEP producers) and when payment mechanisms are already in place. Payments for the water service can then simply be added to existing channels – for instance domestic water users can be charged an additional fee for conservation – or more generally part of the revenue from water fees can be allocated to conservation. The town of Heredia, in Costa Rica, chose the former option, adding an 'environmentally-adjusted' water fee to its utility bills[284]. Conversely, Quito in Ecuador has adopted the latter approach[285]. In Costa Rica, hydropower producers have absorbed the cost of conservation payments into their costs of operation[286]. Where users are not already organised or lack a payment mechanism, the costs of capturing benefits are likely to be substantial.

Scale also has an effect. At small scales, cause-and-effect relationships are easier to establish, the number of actors is limited, and short distances ease the task of negotiating agreements: as the scale increases, all these factors become harder to determine and it can become exceedingly difficult to identify the impact of particular factors, such as land use change in a specific part of the watershed. A larger scale also brings more actors and often different actors. Not only will it be more difficult for downstream users to agree on common action to protect the upper watershed, but there may well be significant differences in needs. Finally, greater distance adds to the transaction costs of negotiating

agreements and monitoring compliance. It is not surprising, therefore, that most successful efforts to date have been undertaken at a relatively small scale.

Actors

Commercial enterprises, various levels of government, local and international NGOs, donors, community groups, and individual land users all participate in markets for forest environmental services as buyers, sellers, intermediaries, brokers, and providers of support services. It is difficult to pigeonhole participants according to their main function, since most play different roles depending on the case, although some likely roles can be identified as outlined in the following paragraphs[287].

Commercial companies stand out as increasingly important buyers of environmental services, with for example private hydropower and water supply companies being frequent participants. In Costa Rica, several private HEP producers agreed to participate in the PSA programme long before the state-owned power producer CNFL came on board. Costa Rican HEP producers see watershed protection as essential to their commercial interests. In other cases, enterprise demand may depend on government regulations. The Clean Water Act in the USA, for instance, is the principal reason for growing payments for wetland conservation by real estate developers.

Governments also play an important role. In addition to developing policy and regulatory frameworks, governments may be significant buyers and sellers of services and they are frequently active intermediaries. For example municipal water suppliers and government-owned HEP producers are notable public sector buyers of watershed services. Brazil's ICMS-E system offers an interesting example of how state governments "buy" watershed protection from municipalities. ICMS-E allocation rules act as an implicit 'price list' for the environmental services the government wishes to buy and municipalities have responded by supplying them. Government agencies that manage forests often suffer chronic budget shortfalls and they increasingly view market mechanisms as a key component of long-term financing strategies, thus also becoming "sellers" of services. Ecuador's Ministry of Environment, for instance, has been a major driver behind Quito's emerging water fund, which it expects will fund the management of the Cayambe Coca and Antisana Ecological Reserves. Governments can also catalyse market mechanisms not only through regulatory action but by offering intermediary services that link buyers with sellers. Governments may also stimulate market payments through the provision of information, advice, and training.

Local NGOs and community groups often play a crucial role by working with smallholders to deliver service supplies, or by organising service buyers. In Quito, local environmental NGOs will implement watershed protection activities. On the demand side, community user groups are expected to help bring small-scale water consumers into the market for Quito's watershed services.

Donor organisations and international NGOs have likewise contributed in different ways to the development of markets for environmental services. Some have been important buyers of global environmental services and donor agencies and international NGOs have also facilitated the establishment and management of market mechanisms, helping to overcome start-up costs and technical constraints. The World Bank is playing an important role in this regard, by helping countries develop PES systems, studying PES efforts to derive best-practice guidelines, and undertaking capacity-building efforts in this area.

Developing effective compensation systems

PES programmes will only have the desired effect if they reach the land users in ways that influence their decisions on how to use the land; several general principles can be identified.

Make payments continuous and open-ended
In general, payments for environmental services should be on-going. In Costa Rica's PSA programme, for example, payments for forest conservation contracts are for 5 years, but they are renewable indefinitely by mutual agreement. Ending payments creates the risk that land users will revert to their previous land use practices. The only exception to this rule may come in situations where the desired land use practices would in fact be the most profitable for land users were it not for high initial costs.

Target payments
An undifferentiated payment system that pays everyone the same will be much more expensive than a targeted scheme. It will also make it difficult to tailor interventions to the particular requirements of given situations. Interventions should be targeted both geographically and according to the land use being implemented. Costa Rica's PSA programme was completely untargeted, with any land user eligible for participation, but has over time evolved towards increasing use of targeting. Providing a differentiated payment for different land uses is also important, as there are often several land uses that might contribute to providing the desired service, but not all to the same extent. A targeted payment scheme may, however, be more expensive to implement than a non-targeted one. A balance needs to be found between the efficiency advantages and the higher costs of better targeting.

Avoid perverse incentives
There is considerable danger that payments might provide perverse incentives, if they are not designed carefully. For instance perverse incentives can be created by limiting PES to "incremental" benefits, such as payment for reforestation (which would generate additional benefits) but not for existing forest cover (which is already generating benefits, and so would not be "incremental"). This risks continued deforestation in areas not covered by payments, thus negating benefits from reforestation, and also a broader risk that non-participants in surrounding areas would postpone adopting beneficial conservation practices because they are waiting for a project to come and compensate them for doing so[288]. One way of avoiding this is to allow for a payment to be made for pre-existing environmental services, albeit at a lower rate than incremental services.

Establishing the institutional framework
PES programmes require a supporting institutional infrastructure. Market participants must have access to information on the value and volume of the services being exchanged. Participants must have opportunities to negotiate payments. Property rights to service commodities need to be clearly defined, and ownership has to be assigned. Monitoring and enforcement mechanisms are required. A network of supporting regulatory and institutional arrangements may be necessary if markets are to function effectively. Establishing such market infrastructure is not easy and is rarely cheap.

Some caveats
Payment for Environmental Services cannot solve all conservation problems, but instead is applicable primarily in cases in which land uses provide substantial benefits to groups other than the land users. (Land use change is not always the cause of downstream problems: sedimentation, for example, sometimes arises from poorly constructed roads rather than from deforestation.) Even when PES may in principle be part of the solution, it may not always be possible to implement. The scientific understanding of forest-hydrology linkages may be too weak to convince downstream users that forest conservation would be a cost-effective means of obtaining the water services they desire. Or it might be too difficult to reach agreement among a large group of diverse downstream users. On the supply side, the transaction costs of contracting with many small, dispersed smallholders with insecure property rights may be so high as to make the approach prohibitive. In general, a wide range of instruments is likely to be needed with PES being seen as one of many tools in a toolbox.

In theory, PES can play an important role in poverty alleviation. The upper watersheds that are critical sources of water services are often inhabited by poor subsistence farmers, and payments for environmental services could be an important addition to their incomes[289]. This will not happen automatically, however and special efforts are needed to ensure that the poor have access to the new opportunities created by PES programmes.

PES programmes are most likely to be effective when downstream benefits are high (resulting in high willingness to pay) and upstream opportunity costs are low. It may be possible to implement such systems in situations when both downstream benefits and upstream opportunity costs are high, but it will be more difficult to do so because the margins will be small. When downstream benefits are low, in general there is little scope to use such mechanisms, even if upstream opportunity costs are also low.

Conditions that encourage use of payment for environmental services schemes

PES schemes are only likely to work with the right combination of information, user groups, economic values and legislation. The following elements need to be put in place

Hydrological information – a clear understanding of:

- Impacts of particular land management on the quantity, quality and reliability of water supply further down the catchment, including the relative importance of land management as compared with other factors

- User needs with respect to water supply: for example whether users are primarily interested in volume or also in quality and if so which elements of quality

To be worth pursuing PES, land management upstream should be capable of delivering desired and economically valuable benefits downstream

Actors in the market – both buyers and sellers:

- Identifiable user groups that are willing and able to pay for environmental services (ideally these should already be organised into definable groups to ease negotiation)

- Identifiable seller groups that would be willing to alter their land management policies in exchange for payments

PES schemes rely on a combination of people in the upper watershed able and willing to sell management services and people downstream capable and willing to buy these.

Economic benefits – enough relative value to make it worth implementing PES

- PES schemes work best when high downstream benefits are associated with low upstream costs.

Finance – in addition to regular payments from users to land managers, most schemes need a source of start-up money, usually from governments or donors but in some cases also from users.

- Such money helps finance initial research, organisations and negotiation

Organisation – a method of collecting payments is required and schemes also need to be monitored and for example charges altered depending on changing economic and hydrological conditions over time

Legislation – many successful schemes have also been bedded within a framework of supportive legislation

In addition, there are some important qualifiers to help make the PES system work; that the payments are:

- Long term
- Targeted
- Designed to avoid perverse incentives

Social overview by **Sara J. Scherr**[††]

Social implications of protecting and managing forests for water supply

Zoning and land use planning can have widely varying social impacts on different groups, and designation of lands and waterways for urban watershed protection is no different. Public or private development of new or enhanced watershed resources creates new assets. How those assets and the social benefits from them are allocated will be influenced by property rights and political factors. Because the livelihoods and welfare of low-income groups in developing countries are especially sensitive to access to water, forest and land, potential social impacts on such groups deserve special attention in developing watershed protection strategies.

Social impacts on the urban poor

Poor urban dwellers are clearly at serious risk to health and livelihood from the present and future threat of inadequate supply and quality of water for domestic use. However, the most straightforward way to ensure access for poor and vulnerable households is through the urban water distribution system. Domestic consumption accounts for only a modest share of total water consumed, and consumption by the poor is only a modest share of that total, so that major improvements in water availability for the poor could be ensured by extended piped water and sewage infrastructure, pricing water so that minimal levels of consumption are very inexpensive, and providing good maintenance for water-related infrastructure.

Maintaining extensive unbuilt green space in protected watersheds and along waterways within the city may provide positive aesthetic and recreational benefits to the poor. They may also provide nutritional, health and economic benefits from harvesting useful foods, medicines and raw materials from natural vegetation, and harvesting edible fish and amphibians from streams, rivers and wetlands.

For low-income peri-urban populations who collect their domestic water (and aquatic food) directly from urban rivers, streams and reservoirs, reduced water contamination resulting from good upstream watershed management may have dramatic impacts on human health. These benefits will not be realized, however, unless water quality in these sources is also protected by good management within the city, for example, protection for contamination by domestic livestock wastes, food and industrial wastes, and raw sewage. To the extent that low-income urban farmers, livestock owners, processing enterprises, etc. are responsible for such contamination, some negative livelihood impacts may result from improved management to reduce these urban pollutants (similar to those described below for the rural poor).

More indirectly, ensuring a secure supply of high-quality water may be an important factor in determining employment-generating urban investment, particularly for high-water-consuming industries and urban agriculture. Thus there may be strong indirect positive impacts on the unemployed and underemployed urban poor from improving water supply and quality. In China, for example, it is reported that reliability of water services is a major factor in competition between cities for foreign investment.

[††] Director, Ecosystem Services, Forest Trends, 1050 Potomac St., N.W., Washington, D.C. 20036, sscherr@forest-trends.org

Social impacts on the rural poor in urban watersheds

For the rural poor living in and around urban watersheds, decisions to protect, manage or restore forest cover for urban water supply will often have dramatic effects on livelihoods and welfare.

Potential social costs

Because urban interests are more politically powerful than rural interests, policy instruments used historically to protect urban watersheds have often ignored rural people's rights and needs for land, water and forests, with significant negative social impacts for millions of people.

Specific negative social impacts for local rural people living in urban watersheds may result from programmes that:

- Transfer ownership or use rights to land or forests from local people (for example, through land appropriation or rules restricting farming or forestry activity);
- Deny rights of access to public or community land, forest, or water resources on which local livelihoods depend (for example, water sources for domestic livestock, timber for local furniture enterprises);
- Offer payments for watershed services that encourage more powerful actors to seek such benefits by appropriating land, forest or water resources over which local people have weak property rights;
- Establish extensive forest plantations on common lands previously important to local people for livestock grazing, gathering of wild foods and fuel, or farm fallows;
- Forcibly resettle local people outside the catchment area;
- Force farmers to make high-cost conservation investments with little on-site benefit, or to convert land to much less profitable crops;
- Damage or deny access to important cultural or religious sites;
- Reduce employment due to closing of farming, forestry or processing activities; or
- Divert water from local users (domestic, irrigation, livestock, and processing uses), to urban users.

Tens of millions of rural people, particularly in upper watersheds feeding cities, reservoirs and irrigation systems in Asia and Latin America, have experienced these negative impacts. Indeed, watershed protection has sometimes has merely a thinly disguised excuse for massive resettlement or social control of politically and culturally marginal groups. In the face of large and growing rural populations in developing countries (which increased overall by 40 percent since the 1960s), it was difficult for public agencies to adequately police or manage these areas in the absence of local support. Thus, many public programmes in populated areas that established strict forest reserves or attempted to reforest previously cleared farm and grazing lands failed to achieve watershed objectives.

Potential social benefits

This mixed experience with watershed management has led to the development of a variety of new approaches that seek to work with local people as stewards of the watershed. These approaches recognize local rights and management capacity, encourage negotiation around design of watershed interventions, or provide technical and financial support for local communities to invest in improved land management. Local people living in and around critical water catchment areas can potentially benefit in many ways from better protecting or managing existing forests or from restoring forest cover. When designed explicitly for local co-benefits, improved watershed protection and management may, for example:

- Enhance the supply and quality of local water resources;
- Restore depleted local fisheries;
- Increase the availability of fuelwood, building materials, livestock fodder, fruits, medicines, wild foods and other raw materials for household consumption or local enterprises (from new or better-managed forest resources);

- Increase income and employment from local wood-based enterprises from timber and poles produced in sustainable systems compatible with watershed management;
- Protect locally-important forest resources from annexation or invasion by outside settlers, destructive infrastructure, or other threats to forest loss;
- Reduce local health problems caused by exposure to contaminated water and other materials in the local environment;
- Validate the important role that rural people play as stewards of the watershed;
- Pay local people directly for their role in protecting, managing or restoring watershed resources; or
- Provide investment resources for local farm and forest producers to improve productivity and sustainability.

Enhancing social benefits from urban watershed protection

Water policy for most cities around the world has been concerned too narrowly with allocating existing water supplies among competing parties, moving water to consumers, and processing water to remove contaminants. Clearly, careful management of critical natural sources of urban water – to enhance quality, supply and reliability – will be one of the most important governance challenges of this century. However, considerations of social impact should be a central factor in determining the most appropriate strategies to conserve and enhance watershed functions.

Increasing benefits from protected forests

In some urban watersheds, protecting or expanding forest cover will indeed be essential for water management. When that is the case, every effort should be made to embed both biodiversity conservation and local livelihood benefits into forest protection strategies. Multiple-use community forestry can provide supplemental local income from timber, non-timber forest products, hunting, recreation or tourism. Local communities and landowners can be paid explicitly to conserve the forest resource and monitor water quality controls.

Where afforestation is deemed important, planting or regeneration can focus first on the most critical sites from a watershed services perspective. Input from local people can be valuable for identifying sites producing unusual levels of sediment or contamination, or areas of compacted soil or barriers to water flow, that may not show up through remote sensing. Their input can identify areas where there are strong community motivations to increase forest cover, such as around local water sources or culturally important sites.

Alternatives to strict forest protection

It is important to remember that undisturbed forest cover is *not* necessarily essential for good watershed management. Most important is that the landscape performs essential watershed functions: slow the flow of runoff, minimize soil erosion and sedimentation of waterways, filter contaminants and maintain appropriate water chemistry, reduce or increase annual water flow, and ensure groundwater recharge. To also protect terrestrial plant and animal species, land uses must provide adequate food sources, adequate water, nesting areas, protective cover from predators, migratory pathways, and presence of pollinators and other interdependent species; to protect aquatic productivity and biodiversity requires providing appropriate shade and types of debris along stream banks. While undisturbed natural forest and associated under-story native vegetation can often provide these functions most effectively and at a low management cost, well-designed mosaics of other land uses may also provide many of these functions. Where the "opportunity cost" to local people is very high for keeping the land under forest, such alternatives should be actively explored.

Timber and non-timber forest products can be produced commercially, under standards of certification. Crops may be produced using good soil erosion control measures or in agroforestry systems with tree

species that benefit associated crops or livestock, or grow products for sale. Organic production methods can be introduced to replace chemical-intensive farming systems, or vegetative filter strips can be established near streamways to minimize contaminated runoff. Grass cover can sometimes be as effective as tree cover for slowing runoff and enhancing water infiltration, and can be established for dual use as animal fodder. Rather than prohibit farming on steeper slopes, rules can require wide strips of natural vegetation be left at intervals on contours along the slope. Local people can be supported to establish rainwater harvesting systems, and to increase the water use efficiency and drainage of irrigation systems. Financial credit, technical assistance, and marketing support will often be needed to facilitate these changes, and can be financed from urban water budgets or consumer charges. Critical sites for hydrological function (or biodiversity conservation) can be zoned for non-productive use, or farmers and landowners can be compensated for permanent or temporary easements.

Landscape mosaics that intersperse patches of natural forest vegetation with patches of crops, pastures or production forest can strategically protect critical watershed sites and remove the most serious threats to water supply and quality. Upstream riparian systems can thus be strategically linked to urban wetlands and larger protected areas through corridors of natural vegetation, contributing to biodiversity conservation. Meanwhile, one of the most important sources of sedimentation, contamination, land compaction and water flow barriers in many watersheds is poorly designed rural infrastructure—roads, paths, electric lines, mines and human settlements. Thus landscape management for watershed protection will also require more systematic monitoring and regulation of construction sites and methods within rural areas.

Conclusion

Securing urban water supplies in the face of accelerating population and economic growth in both urban and peri-urban areas is a critical challenge for city and regional planning. Strong public demand for water security can drive responses that seriously harm vulnerable populations living in and near water resources and catchment areas. However, this demand could stimulate creative land use strategies that enhance livelihoods, while also enhancing biodiversity and the provision of other ecosystem services. Serious attention to addressing potential social costs and impacts can result in greater net social benefits and greater sustainability of watershed and other ecosystem services.

Part 4: Country case studies

The analysis of cities presented in part 3 is necessarily quite brief in a preliminary analysis of this kind. Below we have looked at some interesting examples in slightly more detail.

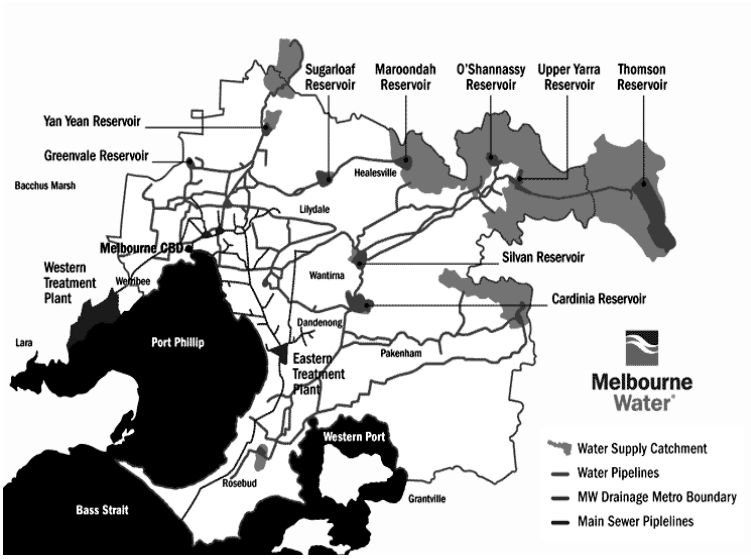
Melbourne, Australia

Introduction

Melbourne is the capital of the State of Victoria and is located in southeastern Australia. The city is centred on the banks of the Yarra River beside Port Phillip Bay. Melbourne has a population of over 3 million people and is the second most populous city in Australia after Sydney. Over the next 30 years, Melbourne's population is predicted to increase by more than 1 million people[290].

Melbourne's water system is highly centralised. Melbourne Water, which is owned by the State Government of Victoria, is responsible for the management of Melbourne's water supply catchments, removal and treatment of most the city's sewage and management of the waterways and major drainage systems – including 3,974 km of streams, creeks and lakes[291]. Three retail water companies (City West Water, South East Water and Yarra Valley Water) manage the reticulation systems, each for a nominated geographic area.

Melbourne Water supplies nearly 500,000 megalitres of water annually to consumers, and is widely regarded as supplying high quality drinking water, mainly due to the purity of the source[292]. Future requirements for water were forecast in the 2002 Water Resources Strategy; with demand by 2020 expected to increase at an average rate of 0.4 per cent per annum, with demand reduction measures, or 0.7 per cent per annum, without demand reduction measures. The ability to manage these increasing requirements will also clearly be affected by the general rainfall pattern in Australia. A seven year drought (1996 to 2002) has reduced the average annual streamflow from the four major catchments by 29 per cent when compared with the long-term average over a 30-year period.



Water source

Ninety per cent of Melbourne's water supply comes from uninhabited mountainous catchments to the north and east of the city[293]. About forty nine per cent of the catchments fall within National Parks, with much of the remaining area being in State forests.

Major catchment areas are:

- Wallaby – 9,100 hectares (within the Kinglake National Park) 1.9 per cent inflow
- Maroondah - 16540 ha (within the Yarra Ranges National Park) 10.8 per cent inflow
- OShannassy - 11870 ha (within the Yarra Ranges National Park) 11.4 per cent inflow
- Upper Yarra - 33670 ha (within the Yarra Ranges National Park) 18.7 per cent inflow

- Yarra Tributaries - 13480 ha (State Forest) - 3.8 per cent inflow
- Thomson - 48700 ha (mainly State Forest and small section Baw Baw National Park) 35.3 per cent inflow
- Sugarloaf, which is not a protected catchment and from which water is pumped out of the Yarra River and fully treated before entering system - 10.7 per cent inflow

About 50 per cent of this 157,000 ha catchment area is covered with the eucalypt species Mountain Ash (*Eucalyptus regnans*)[294]. Melbourne Water manages some catchments just for water collection, and works closely with the Department of Sustainability and Environment and Parks Victoria in managing catchments in state forests and the Kinglake (Category II, 21,600 ha), Yarra Ranges (Category II, 76,000 ha) and Baw Baw (Category II, 13,300) National Parks[295]. Melbourne Water claims that the city is one of only about five cities in the world that has such well-protected catchments[296].

Melbourne's water supply system consists of nine large storage reservoirs, with a capacity of 1,773,000 million litres, which are situated in remote forested areas[297]. The collected water is stored in these reservoirs for one to five years, helping to purify the water through a natural settling process[298].

Protected areas in the catchment

The Yarra Ranges National Park is Victoria's ninth-largest park and is a major water supply source area for Melbourne. The Yarra Ranges National Park has a Natural Catchment Area which is fully contained within the closed Designated Water Supply Catchment Area and represents 84 per cent of the park. A further 2 per cent of the park is also part of a Special Water Supply Catchment Area[299]. The area is recognised for its botanically significant old growth forest and Cool Temperate Rainforest. The park has a relatively low number of annual visitors and is relatively clear of weed infestation and pest animals. The entire Yarra Ranges National Park was reserved in 1995 and a management plan was finalised in 1998.

Kinglake National Park, the largest national park near Melbourne, protects a significant sample of the mostly dry eucalypt forests typical of the foothills and southern slopes of the Great Dividing Range, within the Yarra and Goulburn River catchments. Important features include a high diversity of native plants and animals, including almost 600 native plant species, over 40 native mammal and 90 native bird species. Areas within the Park were first protected in 1928 (5,585 ha) with additional land areas being added in subsequent years including, in 1995, a substantial part of the Wallaby Creek catchment area (9,965 ha). The protected area's management aims, as defined in the Management Plan, include the requirement to: "protect water catchments and streams"[300].

Other catchment management issues

Management of Melbourne's water catchment has been guided by a programme of experimental and analytical research on the relationship between catchment disturbance and catchment water yield, established initially by the then Melbourne Metropolitan Board of Works (now Melbourne Water) and more recently by the University of Melbourne and the Cooperative Research Centre for Catchment Hydrology. Research has been particularly important in clarifying the links between water yield and forest disturbance.

Studies of rainfall and runoff data, collected from large forested catchments in the Melbourne area that were completely or partially burnt by a large-scale wildfire in 1939, concluded that the amount of water yield from forested catchments is related to the forest age[301]. It was found that forest disturbance can reduce the mean annual runoff by up to 50 per cent compared to that of a mature forest, and can

take as long as 150 years to fully recover. This is because evapotranspiration from older forests is lower per unit area than from younger forests. The implication is that forest disturbance, by fire or logging, reduces water yield in the short to medium term (except in the few years immediately after disturbance)[302].

One of Melbourne Waters major management activities in the catchment is to the protected forested catchments against the major threat of bushfires, which as well as destroying the tree cover within the catchment result in soot and ash, which can be washed into the reservoirs. Melbourne Water employs firefighters over the summer period to try to ensure that any fires that occur do not take hold.

Despite there being clear evidence that forest disturbance can have an effect on water yield timber harvesting is still carried out in some part of the catchment. The Thomson Reservoir catchment and the catchments of Armstrong, McMahons, Cement and Starvation Creeks are predominantly State forest and are available for timber harvesting and long-term contracts for timber are in place for these areas. Overall, an average of around 0.2 per cent of the total water supply catchment area is potentially used for timber harvesting each year[303].

Research on the impacts between timber harvesting and water yields is on-going. A research study undertaken in 1992, suggested that with no further timber harvesting combined with the maturing re-growth from the 1939 bushfires would lead to an increase in the Thomson catchment yield of around 17,000ML (or 3 per cent of Melbourne's current catchment yield) within about 20 years. This scenario assumes that the catchment is not affected by future bushfires or other disturbances. A recent hydrology study, however, showed that current catchment yields in forests can be maintained while allowing timber harvesting under the constraints imposed by the Code of Forest Practices for Timber Production and the Regional Forest Agreement[304].

The Department of Primary Industries manages the harvesting operations (in consultation with Melbourne Water) with the objective of ensuring that the timing, intensity and extent of operations are controlled appropriately to protect water yield and quality. Potential water yield is foregone in pursuit of the employment and economic benefits in metropolitan and regional Victoria provided by timber harvesting, sawmilling and paper production activities. All timber utilisation is supposed to be conducted in accordance with the *Victorian Code of Forest Practices for Timber Production*, which contains measures to protect water yield and water quality, including leaving buffer zones along streams, installing drainage on timber harvesting tracks and ensuring that access roads are well maintained. The Victorian Environment Protection Authority conducts audits to assess compliance[305].

WWF has reservations about the continued logging of Melbourne's catchments. WWF is concerned that forest areas of high conservation value in the catchments are not adequately protected, or that the logging practices currently conducted in accordance with the *Victorian Code of Forest Practices for Timber Production* adequately protect the environmental values of the production forests. For these reasons, WWF is unable to support the logging of the catchments, unless and until the forestry operations gain Forest Stewardship Council certification.

Given the likely future deleterious impacts of global warming on rainfall in Victoria, WWF believes the societal value of the water foregone may well be greater than the value of any timber harvested.[306]

Conclusions

Melbourne Water has made a conscious decision to rely largely on protected forest catchments to maintain its water supply, with the result that the city enjoys high quality water at a competitive price. Some of these catchments are in designated IUCN category protected areas so that there is also a clear link between maintaining water supply and maintaining other protected area values including

biodiversity. However, the medium term value of these forests is dependent on them not burning and this may be difficult to achieve in forests that are naturally prone to fire. The recent debate in Australia regarding fires and protected areas suggests that the debate about protection is likely to intensify and may lead to further management controls to reduce fuel build-up in at least the less strictly protected parts of the catchments (e.g. by prescribed burning or selective removals). Here protection and management therefore are closely interlinked in both water management strategies.

Istanbul, Turkey by Ahmet Birsel, Sedat Kalem and Yıldıray Lise[‡‡]

Introduction

Benefiting from a strategically important geographic location and breathtaking natural beauty, Istanbul is situated on both shores of the narrow Bosphorus Straits which joins the Black Sea, to the North, with the Marmara Sea, to the South. Istanbul has been one of the world's largest cities for millennia. Straddling Europe and Asia, Istanbul is the point where east meets west, not only geographically but also culturally, as the city's western part lies in Europe and its eastern part in Asia. The city, founded in 660 B.C. as Byzantium was renamed Constantinopolis under the Byzantine Empire before being conquered by the Ottoman Empire in 1453. It remained the capital until 1923 when the newly emerging Republic of Turkey moved its capital to Ankara. Istanbul is still Turkey's largest city with a current population of over 12 million. One out of every six Turks lives in Istanbul and the city's population density is 1,700 people per km^2. It is estimated that by 2010, Istanbul's population will reach 17 million[307]. The provincial boundaries of Istanbul cover 5,110 km^2, yet supports a remarkably high diversity of plant species with approximately 2,000 species (more than the total floras of the Netherlands or United Kingdom[308].

Water consumption and source

The growing population has lead to an increasing demand for potable water, and in the last decade water consumption has tripled. Water sources in Istanbul are, however, abundant. There are seven ancient water reservoirs and a number of natural springs in the forests on both peninsulas of Istanbul which have been providing water for the city since the 15th and 16th centuries. Most of the major water resources (Terkos, Ömerli, Büyükçekmece, Küçükçekmece and Elmali) are no longer on the periphery of Istanbul as all, except Terkos, have been 'swallowed' by the expanding city limits. The Belgrad forest is located on the European side of the city and hosts several ancient water reservoirs from the Ottoman period. At one time all the drinking water in Istanbul came from Belgrad forest, and was piped to the city's central square, Taksim. The Ottoman Court architect Sinan's magnificent Maglova Aqueduct, built in 1560 to bring water from the edges of the Belgrad forest to the centre of the old city, the 51 km long Anastasius Wall near the Terkos Lake and the well-preserved aqueduct system of the Istranca Roman Water Supply Line dating back 1500 years to Byzantine times are other exceptional historical features

Water for human consumption is currently available from ten sources, typically providing 920 million cubic meters per annum; by 2010 the annual demand for water is predicted to rise to 1.7 billion cubic meters. In order to meet this increasing demand, six new dams have recently been built to bring water from the Istranca forest, an important site for conservation, near the Bulgarian border 200 km west of the city. The water is stored in Terkos Lake, which has caused the original water level to rise and has thus impacted the lakes natural habitats. There are also plans to bring water through pipelines from the Melen River 200 km east.

Problems of urbanisation and pollution

There is significant urbanisation pressure on the Belgrad forest and other forests surrounding the city. Although, forests are the most widespread habitat in the province, together with grasslands, heathlands, sand dunes and wetlands, their continued and rapid destruction is alarming. Nearly six thousand ha of forest have been destroyed over the last 10 years in 872 incidents, some of it caused by intentional fires. Without a concerted effort to protect these areas now, many are likely to be completely destroyed

[‡‡] All of WWF-Turkey

or altered beyond all recognition in the coming years. Not only will this represent an irreplaceable loss of features of international nature conservation importance but it will also result in the loss of already diminished outdoor recreational areas. The probability of such protection taking place is however hampered by the actions of both the national and local government.

The national government is currently promoting an agenda which will not only have an irreversible effect on forest areas nation-wide but will critically affect Istanbul. With the underlying aim of rewarding the political supporters that brought them to power and winning political support in the forthcoming elections, the government is currently proposing a new amnesty for settlers that have illegally occupied forest land. The new law, if passed by the Turkish Parliament, will not only reward those already illegally occupying forest lands but will most likely lead to further destruction of forested areas in the hope of future similar amnesty. For example, forest fires have increased by 35 per cent nation-wide on a year-to-year basis, probably as a result of people clearing land for development, and the population of the Istanbul suburb of Sultanbeyli, developed around the Ömerli Lake, has increased by 2000 per cent in the last 10 years. The government, however, has failed to make the link between the laws they propose and the resulting effect on forest land.

In Istanbul there is also conflict between various governmental organisations and municipalities on the possession, management and authority of water reservoirs and surrounding areas.
For instance, there is a conflict of authority between the Greater Municipality of Istanbul and the Ministry of Environment and Forestry, and ongoing conflicts of authority among the Greater and Local Municipalities especially on urban development, which is affecting even minimal efforts made to protect green spaces. The Ömerli Reservoir, on the Asian side of Istanbul and home to Bern Convention protected heathland habitat as well as critically endangered species, is under growing pressure by developers. The Chambers of Architects, the Chamber of City Planners and the Chamber of Construction Engineers have taken their case to court to stop and reverse the Istanbul Municipality Water Authority's new Drinking Water Catchment Area legislation that will allow construction around the water reservoir catchment area. This development scheme is likely to increase pollution levels in the reservoir and destroy one of the last green areas around Istanbul.

Belgrad Forest

In Turkey, if a forest has an identified special function (providing water, purifying air, preserving soil, etc) it is usually set aside as a special forest which particular management, usually termed a 'Preservation Forest'.

Belgrad is broadleaved forest composed mainly of beech (*Fagus sylvativa*), hornbeam (*Carpinus betulus*), oak (*Quercus frainetto*, *Q. petraea*, *Q robur*), etc. It is jointly managed for research and recreation and because of its hydrological importance. It is not exploited for timber or other resources, but it receives some silvicultural treatment (e.g. thinning) mostly for scientific purposes or to ensure good forest cover. Although the Belgrad forest is called a preservation forest due to its hydrological purpose peripheral areas of forests are being replaced by illegal housing developments due to the rapid migration into the city.

Other threats to Istanbul's forests and water sources include the planned third bridge on the Bosphorus, which will further boost urban development and developments (industrial and residential) in the still well preserved northern green belt of the city, important for water reservoirs which are already confronted by increasing levels of pollution and disturbance. It has also been estimated that the construction of the Istranca water pipeline has destroyed 1,400 ha of forest, and is responsible for deteriorating water quality in Terkos Lake in the European side[309]. The Terkos Lake also suffers from water contamination as a result of intensive agricultural activities around the lake.

The campaign for protection

The forests around Istanbul have been selected by WWF as one of the 'forest hotspots' in Turkey and WWF-Turkey is lobbying the authorities to declare the forests as an official protected area.

Much of the province of Istanbul is of importance to nature conservation, but the Turkish Society for the Conservation of Nature (DHKD, formerly the WWF Associate in Turkey) identified 10 areas as being exceptional due to their high biodiversity. Most of these spots are also important water reservoirs around the town: 1) The Terkos Lake and forests (also identified an Important Plant Area – IPA); 2) The Büyükçekmece Lake (also identified an Important Bird Area – IBA); 3) The Küçükçekmece Lake (an IBA); 4) The Ömerli Lake and forests (an IPA).

WWF-Turkey's campaign started in 1999, with a project titled 'Istanbul Greenspace'. The motto of the project was 'Istanbul: Forever Green'[310]. The project seeks to achieve positive conservation through:

- fostering an appreciation and understanding of the value of Istanbul's unique habitats and rare species through education and public awareness campaigns;
- lobbying for development, introduction and implementation of effective planning and other land management policies to protect valued wildlife throughout the province;
- providing the best scientific information available to town planners and other land managers to ensure that nature conservation interests are fully taken into account of during planning and other land management processes;
- working with other NGOs, authorities, and individuals to secure formal protection for the most valued areas;
- advising on the best management practices to maximize the nature conservation benefits within individual sites; and
- fighting to halt destructive developments.

This campaign was later included within the framework of WWF's Gift to the Earth Campaign, which aims to create new protected areas in Turkey's nine forest hot spots including the Forests of Istanbul. In 2002, WWF-Turkey, in collaboration with relevant stakeholders, started the process leading to the creation of a new protected area with Terkos Lake as the core. Stakeholder workshops have been organised and a justification report was prepared and submitted to the Ministry of Forestry for necessary procedures. The process has yet to be completed due to the unstable political conditions the country has been experiencing.

In 2000, WWF-Turkey also launched a platform called Istanbul Water Initiative (IWI), with the participation of key stakeholders, including experts, NGOs, relevant organisations and individuals in order to monitor the water issues of Istanbul.

Conclusion

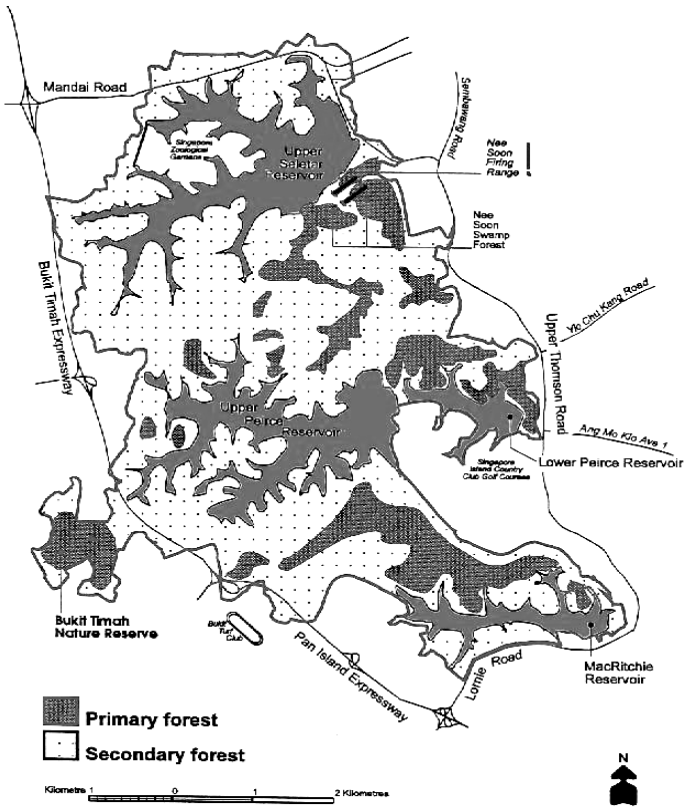
Despite their high value from a water perspective and for biodiversity and cultural reasons, only tiny areas of forest have been set aside for nature conservation and outdoor recreational activities in and around Istanbul. Within the city itself, the total urban greenspace formally set aside by the municipalities covers just under 900 ha. This equates to only an average of 1.13m^2 per person and compares very poorly with the 40m^2 set aside, on average, per person in Europe. In addition, a further 0.96m^2 of natural parks and reserves is set aside per inhabitant. Outside this metropolitan area very few areas have been formally designated for protection: just a handful of nature reserves, game and wildlife reserves and natural heritage sites have been declared[311]. WWF-Turkey hopes that its campaigns will reverse the trend of forest loss, in terms of quantity and quality, in Istanbul, protecting forests for biodiversity and the cities supplies of drinking water.

Singapore by **Wang Luan Keng**[§§]

Introduction

Singapore (1°09'N, 103°36'E) is located off the southern tip of the Malay Peninsula, approximately 137 km north of the Equator. It has a total area of 648 km^2. The island has scarce natural resources, including water. The centre of the island consists of a series of low hills of granite and igneous rock, the highest, Bukit Timah, stands at 176 m. The coastline is mostly flat and muddy although 5,400 ha of this have now been reclaimed[312].

Before the arrival of the British, when Singapore was still a small fishing village, most of the island was covered with 82 per cent lowland everygreen dipterocarp rainforest, 13 per cent mangrove and 5 per cent freshwater swamp[313]. However, while more than 60 per cent of the island was still forested in 1848, by 1882 only seven per cent of that forest cover remained[314]. From 1819 onwards, the forests were being cleared for gambier plantations, which were abandoned after about 15 years due to depletion of nutrients from the soil. After 1900, rubber became the principal plantation crop. Although forest protection began in the 1840s and forest reserves were first established in 1882 to protect the water supply, prevent soil erosion and improve the climate[315], by 1936, all existing reserves except for Bukit Timah and parts of the Pandan and Kranji mangroves, were revoked and regazetted in 1939. Today, the only rainforest areas under protection are in the Bukit Timah Nature Reserve (164 ha) and the adjacent Central Catchment Nature Reserve (about 2000 ha) – IUCN Category IV protected areas. Together they comprise ~ 4 per cent of the original rainforest. These forests are managed by the Singapore National Parks Board.



Map of the Central Catchment Area showing the major vegetation types of the Nature Reserves. The major continuous areas of primary forest are at Bukit Timah Nature Reserve and around the Nee Soon Firing Range.

Population Growth

A century ago, Singapore had a total population of only 230,000.
Since 1901, the population has grown 16-fold to 4,017,700 by the year 2000.

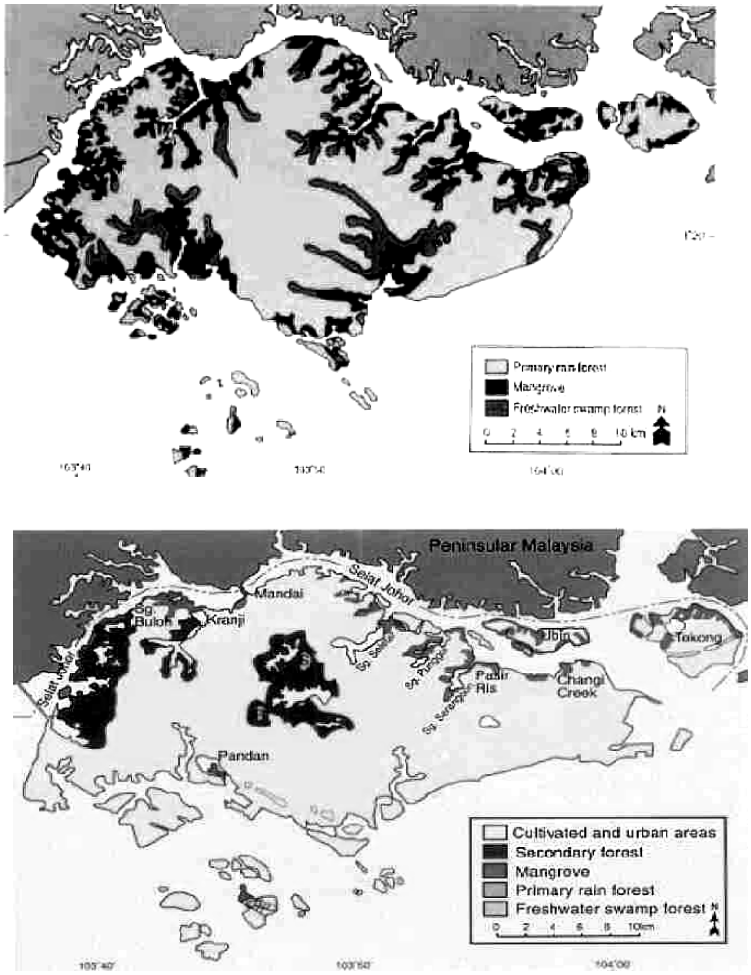
[§§] The author acknowledges Ms Margaret Hall for providing reference material and personal notes about the central reservoirs, Ms Tan Beng Chiak for all the photographs and Dr Shawn Lum for kindly reviewing and commenting on the manuscript.

Population growth peaked at 4.4 per cent per annum during 1947–1957, largely due to the post-war baby boom. The growth rate subsequently declined to 1.5 per cent per annum during 1970-1980. Since then, the average annual growth rate for the population has been increasing, reaching a rate of 2.8 per cent for the period 1990–2000. Non-residents contributed significantly to the population growth, with a high growth rate of 7.6 per cent in 2001 (compared to that of resident at 1.7 per cent) and around 9 per cent per annum (compared to that of resident at 1.6 per cent) throughout the period 1970-2000[316]. The population is expected to grow and reach a peak of 5.5 million.

Water Source

When Singapore was founded in 1819 as a British trading port, freshwater on the island colony came from wells and rivers. However, these freshwater supplies became insufficient to meet the increasing demands by the growing population of immigrants, drawn to the small island by the opportunities for trade and money-making.

Plans to build the first impounding reservoir in an area known as Thomson Road were proposed as early as 1823 but the reservoir was only completed in 1863. The reservoir was created by damming the Whampoe River[317]. The pumps and distributing network were not completed until 1877. Two pumping stations were built at MacKenzie Road and Mount Emily. Singapore's first waterworks officially opened in 1878. In order to keep water as clean as possible, all human activities, including logging, planting, etc, around the perimeter of the Reservoir were banned. The surrounding area of mostly secondary forests was protected by Government gazette in 1868, five years after the completion of the reservoir[318].



Maps showing the major vegetation types of Singapore at 1819 (upper) and today (lower) [after Turner *et al.* 1994]

In 1891, the Impounding Reservoir, as it was then known, was further enlarged under the supervision of the Municipal Engineer James MacRitchie. MacRitchie Dam was enlarged between 1891 and 1894. The dam was further raised by 1.5m in the period 1903-1905 to increase its storage capacity. The cost of the extension was S$32,000 and it increased the capacity of the reservoir to over 1840 million cubic metres (468 million gallons). The enlarged reservoir was named the Thomson Road Reservoir in 1907 but in 1922, it was renamed MacRitchie Reservoir to recognise James MacRitchie's work.

By the beginning of the 20th century, the average daily supply of water was about 4 million gallons – not enough to meet the demands of 230,000 people. A combination of drought and increased demand

led to water shortages and more plans to increase the water supply. One plan was to channel water from the upper section of the Kallang River into the Thomson Road Reservoir. Another was to build a service reservoir in Pearl's Hill. To take the water from the Upper Kallang, Thomson Reservoir was extended in 1905. The Kallang Tunnel Works were completed in 1907.

In 1902, the Municipal Engineer Robert Peirce had come up with a plan to create a second impounding reservoir across the lower reaches of the Kallang River. It would have created a storage capacity of 3.2 million cubic metres (845 million gallons). Known as the Kallang River Reservoir, this scheme was completed in 1900 and the surrounding forest protected in 1910[319]. This reservoir was expected to supply an extra 27-30 thousand cubic metres of water daily, boosting total supply to some 55 thousand cubic metres. This was considered adequate to meet demand until 1915.

Officially commissioned in 1912, the Kallang River Reservoir was renamed Peirce Reservoir in 1922 after the Municipal Engineer Robert Peirce who had been in charge of its construction. It became known as Lower Peirce Reservoir when work began on an even bigger impounding reservoir in 1975. The Upper Peirce Scheme was built a cost of S$55 million. It entailed the construction of a dam and ancillary works at the upper reaches of the old Peirce Reservoir. Water from the Upper Peirce Reservoir is treated at the Chestnut Avenue Waterworks.

Water demand surged after the First World War, and work on the latest of the Central Catchment reservoirs, the Seletar Reservoir began by damming the upper reaches of the Seletar River[320]. Singapore's third impounding reservoir was thus built in 1920.

In the early 1960s, work began to quadruple the capacity of Seletar Reservoir to 20 million cubic metres (5.3 billion gallons). The reservoir was enlarged by over 35 times. The natural run-off from the catchment upstream of the dam is augmented by water pumped from eight adjacent streams into the Seletar Reservoir. The water from the enlarged Seletar Reservoir is transferred to Lower Peirce and thence to Woodleigh Waterworks. Woodleigh Waterworks also had to be expanded to cope with the increased volume of water. The reservoir was Singapore's largest reservoir and was built at the cost of $27 million. It was renamed Upper Seletar Reservoir in 1992.

The four impounding reservoirs, located in the central part area of Singapore, were surrounded by 2059 ha of mostly secondary forests, which form the Central Water Catchment, ensuring a clean supply of water to the reservoirs. Bukit Timah Hill has a small amount of water, one side of it flows into the Rochor River.[321] Another side flows towards Upper Peirce Reservoir.

As demand for water continues to increase with the increasing population and industrial growth, the development of impounding reservoirs became impossible in land scarce Singapore. The establishment of more forested catchment areas would mean depriving other important needs such as housing. Other non-conventional ways of water collection were explored and major water supply schemes were completed. The Kranji/Pandan Scheme which comprised Kranji Reservoir was created in 1975 by damming the estuary of the Kranji River, and Pandan Reservoir, by building a dyke to enclose a mangrove swamp. As the water within these dammed estuaries was brackish, they initially had to be pumped out regularly to reduce the salt content.

Another major scheme, the Western Catchment Scheme started in 1977 and was completed in 1981 at a cost of S$67 million. Four estuaries – Murai, Poyan, Sarimbun and Tengeh were dammed and converted into reservoirs.

In 1986, the Sungei Seletar/Bedok Water Scheme was completed. The scheme involved the damming of Sungei Seletar to form a reservoir (Lower Seletar Reservoir), creation of Bedok Reservoir from a

former sand quarry and construction of Bedok Waterworks. Its unique feature was the construction of nine stormwater collection stations to tap the storm runoffs of the surrounding urbanised catchments. Eight of these collection stations are ponds at Yishun, Tampines, Bedok and Yan Kit new towns.

Water management authorities

The Public Utilities Board was inaugurated on 1 May 1963 to take over the responsibility of providing electricity, water and piped gas from the former City Council. Under the Public Utilities Act, Chapter 261, the Board is to provide, construct and maintain such catchment areas, reservoirs and other works as may be required or necessary for the collection, supply and use of water for public and private purposes. Over the last three decades, several major water supply projects were undertaken by the Board to develop new water resources to support Singapore's rapid housing and industrialisation programmes.

Permission was granted by the government of the Malaysian state of Johor to seek a source of water from the state. Singapore has been receiving water from Johor as early as 1924, when the Gunong Pulai Scheme was started, where dams were built to form the Gunong Pulai and Pontian Reservoirs, a steel pipeline for pumping water from Pontian to Gunong Pulai, which also had a treatment plant. Treated water is pumped from Gunong Pulai to a service reservoir at Pearl's Hill in Singapore. By 1941, Gunong Pulai's treatment capacity was doubled. In the 1980s, water treatment capacities in Johor were extended. A pipeline was laid from the Johor River Waterworks to Singapore, across the Straits of Johor. The treated water goes to a covered service reservoir. If any raw water comes in at all, it goes into Upper Peirce Reservoir, which is then pumped to the Chestnut treatment works[322]. Water from Upper Seletar goes along that channel to Lower Peirce and then to Woodleigh. Water from MacRitchie goes to the Bukit Timah treatment beds. The island state now receives half of its approximate 300 million gallons per day usage from Johor. Another 150 million gallons needed daily come from the Central Catchment Reservoirs themselves.

In the past three decades, the water supply system has been extensively expanded to support Singapore's rapid economic developments and the attendant increase in water demand. Current total water supply comprises of nine water treatment works, 19 raw water reservoirs, 14 storage or service reservoirs and more than 5,000 kilometres of pipelines. These collect about 68, 000 cu m of rainwater daily, which is about 57 per cent of the daily consumption needs of about 1.2 million cu m[323]. The daily consumption of water in Singapore is expected to increase by 33 per cent in the next ten years[324].

To augment Singapore's water supply, the Public Utilities Board (PUB) has plans to further collect stormwater from residential new town developments as well as capture surface runoffs from highly urbanised catchments. More housing estates and built-up areas will soon channel stormwater into local reservoirs. Storm water collected in drains will also be channelled into reservoirs. Another reservoir will be created at the Marina basin in the south of the island. New reservoirs are being developed downstream of the present Lower Seletar Reservoir. The PUB is also looking into additional water supply from desalination of seawater. Desalination has become a feasible option due to rapid technological advancements in the last few years, resulting in lowering of costs. PUB will be purchasing desalinated water from the private sector through a Build-Own-Operate project. Desalinated water supply is targeted to be available in 2005.

Since May 2000, the PUB commissioned and has been operating an advanced water treatment plant using the latest membrane technology including reverse osmosis to purify treated wastewater (from sink and bathroom). The resulting high quality product water (called Newater) is suitable for supply to the industrial users that require copious amounts of pure water for wafer fabrication and other uses. From February 2003 onwards, the Singapore Government has given the go-ahead for two million

MacRitchie Reservoir

gallons of Newater to be blended with raw water supplies in Bedok, Kranji and Upper Seletar Reservoirs, after a panel of nine members endorsed the Newater safe and substainable[325]. This will help to diversify Singapore's water sources and also meet the anticipated rising demand for water in the future.

Future of watershed protection

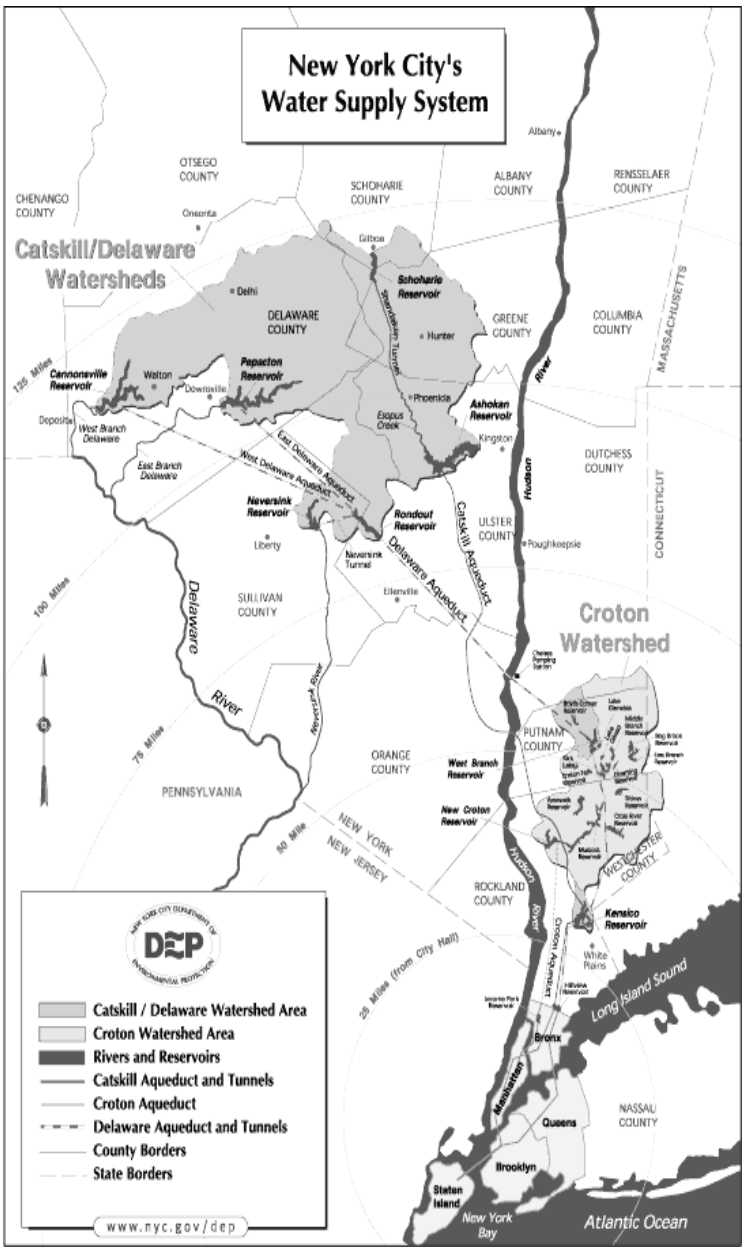
While protected catchment forests played a major role in ensuring an adequate supply of water during Singapore's formative years, enormous increases in the demand for water had led to the development of unconventional, non-traditional water supplies. Given that Singapore forests exist primarily for the sake of the island's water supply, it may lead one to wonder how secure these forests are should their role diminish further as contributors to Singapore's total water supply. Over the last 183 years, Singapore has suffered substantial rates of documented and inferred extinctions, especially for forest specialists, with the greatest proportion of extinct taxa (34 – 87 per cent) in butterflies, fish, birds and mammals. Although forest reserves today only cover 0.25 per cent of Singapore's area, they harbour over 50 per cent of the native biodiversity left on the island[326].

New York, United States of America

Introduction

New York is one of the many cities across the USA where watershed management and protection play an important role in providing water to its citizens. Management regimes are based on developing partnerships with landowners and users and a range of incentives.

New York is one of the most densely populated cities on the planet. The nine million residents of New York City and surrounding areas receive their drinking water supply predominantly from the rural Catskill and Delaware watersheds and the smaller and more industrialised Croton watershed[327]. Together, the three watersheds deliver 1.3 billion gallons of water per day to New York City and the metropolitan area. The watersheds of the three systems support reservoirs fed by the watershed that have a combined storage capacity of 580 billion gallons.



Water source

New York's watershed is actually divided into two separate systems – the Catskill/Delaware Watershed and the Croton Watershed. The Catskill/Delaware Watershed, located approximately 100 miles northwest of New York City, provides 90 percent of the City's drinking water. It covers over 1,600 square miles of land in five counties, and consists of six major reservoirs – the Ashokan and Schoharie Reservoirs of the Catskill System and the Rondout, Neversink, Pepacton and Cannonsville Reservoirs of the Delaware System[328]. The Croton is the city's oldest system dating back to 1842. It covers about 380 square miles and supplies about 10 per cent of the city's needs[329]. Forests constitute 75 per cent of the total land area in these watersheds[330]. Land ownership is diverse, with New York City owning less than 10 per cent of the watersheds that supply the city with water[331].

The Catskill State Park (Category V, 99,788 ha) overlaps significantly with the watersheds of the Catskill/Delaware system. The park contains 98 peaks of over 3,000 feet high and is a blend of public and private ownership (over 60 per cent is privately owned). The Catskill Forest Preserve is state land now contained within the Catskill Park[332] and protects approximately 25 per cent of the watershed from further development.

A watershed agreement

On January 21, 1997, New York State Governor George E. Pataki, and New York City Mayor Rudolph Giuiliani joined the United States Environmental Protection Agency, the Coalition of Watershed Towns and members of the environmental community in the signing of a landmark 'Memorandum of Agreement' for the long-term protection of water quality in the New York City Watershed[333].

The Watershed Agreement resulted from discussions as to how to manage issues of water quality in the Catskill/Delaware Watershed. There are approximately 400 dairy and livestock farms in New York City's watershed and agriculture poses a potentially significant source of pathogens, nutrients and other forms of pollution to surface waters[334]. The quality of the drinking water was first questioned in the late 1980s as concerns began to grow about possible microbial contamination. In 1989, the United States Environmental Protection Agency (EPA) instigated a requirement that all surface water supplies to cities should be filtered; however this requirement could be waived if existing treatment processes or natural conditions provided safe water.

Achieving clean water

New York City (NYC) has introduced a range of initiatives to achieve its aim of improved water quality. These include:

Financial aid:

- *Taxation*: NYC residents voted to allow the government to levy additional taxes on their water bills.
- *New York City Bonds*: NYC issued bonds for additional financing.
- *Trust Funds*: NYC financed the Catskill Fund for the Future, a US$60 million trust fund that provided loans and grants for environmentally sustainable projects in the Catskill watershed. Another Trust, the NYC Trust Fund, provided US$240 million for water quality and economic programmes in the Catskill watershed and US$70 million for programmes in the Delaware watershed.
- *Stormwater Controls:* NYC will pay all of the incremental costs of designing and implementing stormwater pollution prevention measures required by the regulations for certain residential projects and half of the costs for small businesses.
- *Good Neighbor Payments:* NYC has provided up to US$9.765 million for municipal capital projects to help establish a better working partnership with communities in the Watershed.

Compensation:

- *Cost-sharing /Subsidy Programme*: NYC provided US$40 million to dairy farmers and foresters who adopted best management practices. Of the approximately 350 Catskill/Delaware dairy farmers, 317 agreed to participate in the programme.
- *Logging permits for forest management improvements*: In return for improving forest management practices, such as the adoption of low impact logging, the timber industry gets additional logging permits in areas to which they had no prior access.

Conservation measures:

- *Land Acquisition*: NYC is acquiring land and conservation easements in hydrologically sensitive areas– such as that near reservoirs, wetlands, and watercourses. NYC has also created a farm easement program, with its partner the Watershed Agricultural Council, to protect farms from development and to establish best management practices. Such lands and easements are acquired at fair market value from willing sellers only; the City pays property taxes on all such lands acquired.
- *Stream Corridor Protection:* Design, construction and implementation of stream corridor protection projects such as streambank stabilisation and fish habitat improvements, in the Watershed.
- *Other Land Management Programs:* Under the federal Conservation Reserve Enhancement Program farmers and forest landowners can enter into 10 to 15 years contracts with the United States Department of Agriculture to remove environmentally sensitive lands from production. Forest landowners who own 50 acres (20 hectares) or more and are willing to commit to a ten-year forest management plan are also eligible for an 80 per cent reduction in local property tax.

In response, New York City committed to building a filtration plant for the Croton watershed but in the Catskill/Delaware watershed the authorities developed a programme of watershed management improvement. The Agreement signed in 1997 is a legally binding document which sets forth certain obligations by the parties involved on issues relating to the protection of the watershed. This is based in part upon improvements in farm and forestry practices that aim to reduce significantly microbial pathogens and phosphorous in water supplies (see box for a summary of the measures included in the initiative). The programmes aim is to improve water quality, thus making additional purification unnecessary. As a result of these actions the city received a temporary filtration waiver from the EPA; however there is no guarantee that the initiative will be successful in achieving the desired standards of water quality in the time allotted in the EPA waiver[335].

The City of New York paid the initial costs and lion's share of the watershed programme, with state, federal and local governments within the watershed area providing supplementary funding. The construction costs of an additional filtration plant were estimated at US$6-8 billion, plus an annual US$300-500 million operating costs. The alternative watershed programme will cost the city US$1 to US$1.5 billion over ten years. The programme was primarily financed by a 9 per cent increase in water taxes a five-year period; a tax rise that compares favourably with the alternative doubling of taxpayers' water bills that would have been needed to build a new filtration plant[336].

Protecting the watershed

Although all the initiatives developed as part of the 'Memorandum of Agreement' are based upon achieving the goal of the long-term protection of water quality, two programmes in particular are likely to particularly benefit conservation and forest protection in the watershed.

The Land Acquisition Program allows the New York City Department of Environmental Protection (NYCDEP) to purchase property in the Catskill/Delaware and Croton Watersheds. One of the main purposes of the program is to enable the City to develop a 'buffer' around reservoirs, their tributaries and other important land features to protect water quality. Under the terms of the Agreement, the City is required to approach the owners of 143,795 ha of eligible land in the Catskill/ Delaware Watershed (approximately 30 per cent of the watershed area) and must commit from US$250 to $300 million for acquisition. (It should be noted that the programme is voluntary and that this target is for contact only and does not mean that the City will acquire this much land). In order to maximise the effectiveness of the programme, the NYCDEP has developed criteria to evaluate the watershed and categorized priority areas eligible for acquisition. In most of the watershed, the City is only allowed to acquire vacant parcels of land, i.e. areas containing no structures other than uninhabitable dwellings. Once land has been acquired, management will focus on maintaining water quality, although recreational uses, such as fishing, hiking and hunting, may be allowed to continue on property in such cases where NYCDEP determines that it will not conflict with water quality and public safety[337].

The other tool, specifically aimed at conservation is the conservation easement – a covenant or restriction placed on a piece of property which limits development, management or use of the land in perpetuity. Property owners may sell conservation easements to the City to protect their land from inappropriate development, while retaining private ownership. In particular, conservation easement provides a mechanism for protection of property owned by people who are not necessarily interested in selling outright, but who wish to receive financial benefits for being good stewards of their land.

Protected areas in the watershed

The state-owned Catskill Forest Preserve was created in 1885, growing from an original 13,770 ha to almost 121,500 ha today. Since 1904, the Forest Preserve has been part of the larger Catskill State Park. The Park is reminiscent of the European model of national parks and is a mix of private and public ownership and habitats and usage. Most of the mountain peaks within the Park are protected, and thus provide drinking water for local people as well as millions of others in the lower Hudson Valley and New York City. The Ashokan, Rondout, and part of Neversink and Pepacton Reservoirs are found in the Park.

Coyotes, bears, bobcats and minks are found in the forest preserve and red squirrels and porcupines are common at higher elevations in balsam fir (*Abies balsamea*) and red spruce trees (*Picea rubens*) of the boreal forest. Old growth forests of hemlock (*Tsuga canadensis*) and others northern hardwoods survive on steep mountainsides and remote valleys, as they were inaccessible to the logging, tanbarking and charcoal industries that have taken place in the area over the last 300 years. Although many of the areas formerly logged have regenerated, forestry remains important on private lands, primarily as a source of lumber[338].

Conclusions

If all goes to plan, the land and forest resource protection strategy will result in substantial savings for New York City as compared with putting in a treatment plant. The strategies start-up costs being estimated at US$1 to US$1.5 billion over ten years, as opposed to US$6-8 billion, plus an annual US$300-500 million operating costs, that would be required for a treatment plant. The plans have general support from the citizens of New York. However, it remains uncertain as to whether the benefits will accrue in time to meet deadlines on purification imposed by state laws. Nor is it clear to what extent the protected forests will be classified as IUCN protected areas or not.

Caracas, Venezuela by **José Courau**

Introduction

Caracas was founded in 1567 as Santiago de León de Caracas and quickly became one of the most prosperous Spanish colonial communities in South America. The city became the capital of the Venezuelan Republic in 1829.

Caracas is located in the central section of the Coastal Mountain Range at 950 meters above sea level. The city has seen rapid, and unplanned, urban growth[339]. It is reported that during a period of just 50 years the population grew from 350,000 to over 1.5 million. In 1997 the estimated population was 1.8 million, and the city's population continued to grow at a rate of 2.3 per cent per annum[340]. The trend of migration from the rural areas to the city has been difficult to stop, and it is estimated migration will cause more radial growth around the city, bringing consequent problems for the provision of services and the social and health problems[341].

Water supply

Overall, the northern part of Venezuela, where Caracas is located and where most of the country's population lives, is the one with the least hydrological resources[342]. The city consumes an average of 17 thousand liters of water per second and it is estimated that the average resident uses 500 liters of water per day.

In 1600, Caracas, which consisted of 4 main streets and 2,000 inhabitants, had a water distribution system of pipes made out of clay covered with calcium carbonate. Over a short period of time the system became insufficient. In 1675, the Franciscan priests decided to build a private aqueduct for the exclusive use of the convents, monasteries and churches. These two water systems remained the main methods of water distribution for the next 200 years.

The first officially managed aqueduct in Caracas was opened in 1874. This system consisted of a 46 km canal connected to the Macarao River. Water was stored in a reservoir in the El Calvario hill and from there distributed to central Caracas.

The aqueduct provided 400 litres of water per second for Caracas, a record for the period. For 50 years the aqueduct solved the water needs of the city. As the population increased only two aspects of the distribution system were improved: the 46 km ground canal became a concrete canal and the reservoir at El Calvario was extended. The increasing demand for water led authorities in 1926 to declare Macarao as the first National Forest to protect the origins of the San Pedro, Macarao and Lagunetas rivers. The forest was declared a national park in 1973 (15,000 ha, Category II). The Guatopo National Park (122,464 ha, Category II) was declared in 1958 also with the purpose of protecting water sources (Lagartijo, Taguaza, Taguacita and Cuira Rivers) for the city[343].

The water used by the city is transported from sources located more than 150 km away in an area called Camatagua. From here the water is pumped 600 m: which requires a significant amount of electricity.

It has recently been reported that there are significant shortages of water in the city, due to reductions in the water table and the city's poor water management culture[344].

Water source

The city receives water form three main sources. These sources correspond to three national parks, the Guatopo, the Macarao and the Avila National Parks (85,192 ha, Category II). The Table 1 illustrates the different sectors of the city and the corresponding protected areas that provide them with water.

Water sources for the different population centres associated with Caracas

Population Centre	Population	Protected area
Caracas	1,822,465	Guatopo
		Macarao
		El Avila
Petare	338,417	El Avila
		Guatopo
Barua	182,941	Guatopo
Chacao	66,897	Guatopo
		El Avila
El cafetal	59,949	Guatopo
Los dos caminos	59,141	El Avila
Gran caracas	2,529,810	Guatopo
		El Avila
		Macarao

- **The Guatopo National Park** was declared in 1958. It is recognised as an area of hydrological importance that contributes to the water of the city of Caracas and is managed by the state agency INPARQUES. The water generated by the park is collected in the Lagartijo, La Pereza, Taguacita, Cuira and Taguaza dams[345].

  The park consists of deciduous and evergreen forests. The predominant tree species are the cedar (*Cedrela fissilis*), balso (*Ochroma lagopus*), bucare (*Erythrina poeppigiana*), sangre de drago (*Pterocarpus acapulcensis*), araguaney (*Tabebuia chrysantha*), indio desnudo (*Bursera simaruba*) and yagrumo (*Cecropia peltata*). Palms include seje (*Oenocarpus bataua*), macanilla (Bactris sp.) and the small endemic palm *Asterogyne spicata*. Epiphytes are mainly represented by the aracea, bromeliads, orchids and piperacea. Important fauna species found within the park include *Chironectes minimus*, three-toed sloth (*Bradypus variegatus*), anteater (*Tamandua tetradactyla*), and the endangered *Priodontes maximus*. Various carnivores have been reported, including the jaguar (*Panthera onca*), *Galictis vittata*, *Conepatus semistriatus*, and the kinkajou *Potos flavus*. There are also at least ten species of bird considered endemic or with limited distribution and more than 50 species of bats[346].

  Lack of park personnel is seen as the main threat to the park, along with the threat forest fires.

- **Macarao National Park** was declared in 1973. The park is located in the southeast of the city. It is part of the Coastal Mountain Range and includes the rivers Macarao, San Pedro and Jarillo. The altitude varies from 1000 meters to 2,098 at Alto de Ño León, the highest point of the basin[347].

The park contains semi-deciduous forests, evergreen forests and cloud coastal forests. The predominant tree species are represented by the genus Guarea, Gustavia, Inga, Ocotea and Tabebuia. There are at least 6 species of birds with restricted distribution. In addition, the park includes the blue-chested hummingbird (*Sternoclyta cyanopectus*); the puma (*Felis pardalis*), the howler monkey (*Alouatta seniculus*), the three-toed sloth (*Bradypus variegatus*), the deer (*Mazama americana*), the peccary (Tayassu sp.), paují (Pauxi sp.), guacharaca (*Ortalis ruficauda*) and querrequerre (*Cyanocorax yncas*)[348].

- **El Ávila National Park** was declared in 1958 (66,192 ha) and extended to 85,192 ha in 1974. It is located in the north-central part of Venezuela and inside the central part of the Coastal Mountain Range. It covers part of the Federal District (along the coast) and the State of Miranda (northwest region)[349]. The park includes several springs (Tocomé, Chacalito, Catuche, etc.) that carry water to the Tuy River[350].

  The main ecosystems protected in the park are evergreen forests, cloud forests and savannas. The main importance of the park is as a source of water and for the production of energy[351].

Water management

The management of hydrological resources in Venezuela is responsibility of the Ministry of Environment and Renewable Natural Resources (MARNR) through its Sector General Directorates (DGS). The provision of water and the waste management is decentralized to the municipalities. However, there have been some recent changes. The Hydrological Anonymous Venezuelan Company (HIDROVEN) is now responsible for dictating policy and providing technical assistance to the ten regional water companies, which are commonly referred to as 'hidros'. These regional companies have a technical and supervisory role and are responsible for the production of potable water, the operation and management of water systems, building and rehabilitation of infrastructure, and the policies of charging and collection of fees. The companies also give financial support to the municipalities and promote municipal involvement in the water provision services and the creation of operating companies[352].

Due to the serious financial limitations faced by the protected areas in Venezuela, in 1999 INPARQUES started to consider charging the water companies for the direct services they obtain from the country's protected areas, including water, antennas for telecommunications, admission fees and electricity generation. However, until now this initiative has not been further developed[353].

Rio de Janeiro, Brazil by Claudio Sericchio[***]

Introduction

The city of Rio de Janeiro, capital of the state of Rio de Janeiro and formerly of Brazil, was founded in 1565. Located on the coast of the Atlantic Ocean (22º 54' 10" South and 43º 12' 27" West), Rio has a population of approximately 6 million, making it the third largest urban concentration in Latin America, after Mexico City and Sao Paulo. The larger Rio de Janeiro Metropolitan Area (RJMA) is composed of twenty municipalities, according to the state's administrative division, with a total population in 2000 of nearly nine million people. Estimates of population growth in the RJMA predict this population will rise to over ten million by 2010 and 12.5 million by 2030[354].

Water Supply

The water supply of the city of Rio de Janeiro and the Metropolitan Area is the responsibility of the State Water and Sewage Treatment Company – CEDAE, a public enterprise belonging to the state of Rio de Janeiro. The water comes from a variety of sources (see table).

RJMA Water Supply System (2002)

Supply Systems and Areas	Impoundment capacity (m^3/s)	Distributed yield (l/s)	Supply capacity (inhabitants)	%
1. *Guandu River (Guandu Water Treatment Facility):* Rio de Janeiro city and RJMA	47	40,000	9,600,000	81.2
2. *Lages Reservoir:* Rio de Janeiro city, Itaguai and Paracambi	5.5	5,000	1,200,000	10.1
3. *Other water sources*				
- *Within Rio De Janeiro:* Rio de Janeiro city, Tijuca, Santa Tereza, Gavea, Jacarepagua, Campo Grande and Guaratiba	-	600	144,000	1.2
- *Sao Pedro, Rio d'Ouro, Tingua, Xerem and Mantiquira rivers*: Baixada Fluminense municipalities	-	3,500	840,000	7.1
- *Mazomba and Itinguassu dams*: Itaguai municipality	-	167	48,096	0.4
Total	**-**	**49,267**	**11,832,096**	**100**

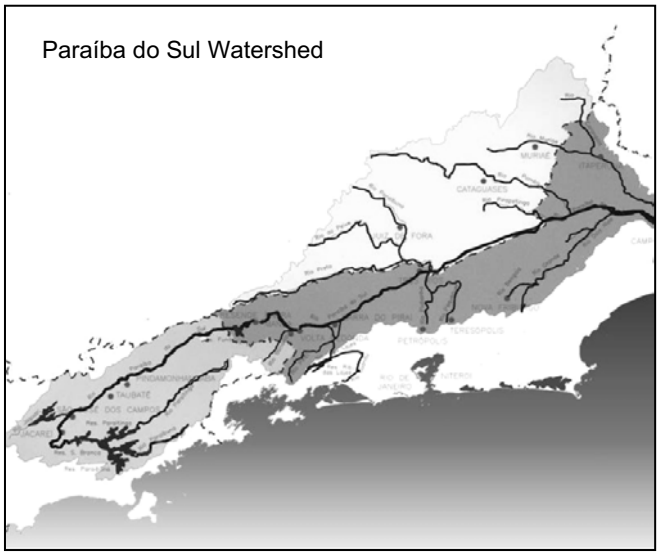
Source: CIDE (2002); Anuário Estatístico do Estado do Rio de Janeiro 2002. CD-Rom. Rio de Janeiro: Fundação Centro de Informações e Dados do Rio de Janeiro and Silva, Rosauro Mariano da (1998); colaboração de Joper Padrão do Espírito Santo. A luta pela água. Rio de Janeiro: CEDAE

1. Guandu River (Guandu Water Treatment Facility)

The Guandu River is the main source of water for Rio de Janeiro. Its flow volume averages of 136.2 cubic meters per second, of which 96.4 per cent is artificially created[355]. The Guandu River Catchment and its tributary, the Lages, have seen major engineering interventions since 1908, when the Lages reservoir was constructed to generate electricity. In 1913, the transport of water to the Guandu

[***] Claudio Sericchio is an engineer specializing in environmental management. Coordinator of the Committee for the Integration of the Paraiba do Sul River Catchment – CEIVAP

catchment began with the building of the Tocos reservoir, in the upper Pirai River – a tributary of the Paraiba do Sul River, and a gravity adduction tunnel for the Lages reservoir. In 1952, the trnsport of water from the Paraiba do Sul to the Guandu catchment was increased, through a system built and operated by the Light Electricity Company. Currently, the Guandu Water Treatment Facility, owned by CEDAE and inaugurated in 1955, is the main supplier of drinkable water for the city of Rio de Janeiro and the Metropolitan Area.



2. Lages Reservoir

The delivery of water directly from the Lages Reservoir was implemented in two stages (1940 and 1948) and added approximately 430 million litres per day to the water supply for Rio de Janeiro, thus solving a major supply deficit at the time. With a storage capacity of 601 million m^3, Lages reservoir is a strategic water reserve for the city. As the water from the reservoir is of high quality, due to forest protection along its watersheds, the water does not go through Guandu Water Treatment Facility and receives only chlorine and fluorine disinfectant treatment prior to distribution[356].

3. Other water sources of Rio de Janeiro and the Metropolitan Area

Several sources of water which supplied the city in former times, until the supply systems from the Guandu and Lages Rivers were developed, are still in use to today. The systems of Santa Tereza, Tijuca, Gavea, Jacarepagua, Campo Grande and Guaratiba, contribute on average nearly 60 million litres of water per day to the city – just less than 9 per cent of the total water supply. Formed by dozens of mountain springs, most have no type of yield regulations[357]. The water is usually impounded in the upper part of the rivers, in forested areas on the hillsides surrounding the city and is treated only with chlorine disinfectant.

Problems of water quality and quantity

The presence of large amounts of suspended sediments originating from hillside erosion causes large variations in the consumption of chemicals needed in the treatment of water from the Guandu Water Treatment Facility. During the annual period of intense rains (November to March), the lack of soil protection in the impoundment catchments increases turbidity and sediment in the water, making treatment difficult and costly. An increase in the chlorine consumption by 32 per cent from 1995 to 2000 is an indicator of the reduction in the water quality from the Guandu River. Overall, chemical products represents as much as 80 per cent of CEDAE's total expenditure[358]. The causes of poor water quality include: deforestation, irregular urban waste disposal, illegal sand extraction along river banks, population growth, open sewage disposal and open industrial waste disposal[359]. Compared with the limited water treatment required by the Lages Reservoir and the other older water supply systems detailed above, where forests around the watershed are protected, it would suggest that it would be cost effective if measures were taken to conserve soils around the watershed.

There are also problems with the quantity of water available, with, for example, the hydrological conditions in the Paraiba do Sul River catchment over the last seven years not providing the expected water yields.

The role of protected areas in maintaining Rio de Janeiro's water supply

The creation of protected natural areas in Rio de Janeiro and its Metropolitan Area began in the 19th Century. The first protected forests were on the Tijuca Massif's, just outside Rio de Janeiro. The forests here were cleared in the 18th century to make room for coffee plantations, as a result, the rivers and streams became silted and in the succeeding years the city suffered severe droughts. By 1861, the situation had become so serious that Emperor Pedro II ordered the expropriation of all Tijuca's farms and the complete reforestation of the area. Manuel Gomes Archer, who was given the task, was an amateur botanist and thus used native species for the reforestation. In 1961, to commemorate the 100th anniversary of Archer's reforestation, Tijuca was proclaimed a National Park[360].

Today, most of these areas are Conservation Units under the terms defined by Federal Law no. 9,982 of July 18, 2000, which instituted the National System for Protected Natural Areas – SNUC. However, the drainage catchments of Paraiba do Sul, Pirai, Lage and Guandu Rivers, which are now the main sources of water supply for the RJMA, do not have the same protection status as the older water sources, due to their vast extension and intense occupation. Instead, the Biosphere Reserve concept has been used to protect these watersheds and Atlantic Forest remnants. The Atlantic Rainforest biome, where all watersheds for RJMA are located, was declared a Biosphere Reserve by the UNESCO Man and Biosphere programme (MaB) in 1991. The territorial limits of the Atlantic Rainforest Biosphere Reserve in the state of Rio de Janeiro, located in physical-geographical region no. 8 (Neotropical Region), in bio-geographical province no.7 (Serra do Mar), and in biome group no.1 (Tropical Rainforest), were ratified on October 8, 1992. The mountainous areas of the Paraiba do Sul river catchment and practically all catchments of the Pirai River and Lages reservoir are within this reserve however few effective conservation measures have yet to result from this declaration. The Atlantic Rainforest is also considered a National Heritage according to Brazil's 1988 Federal Constitution (Chapter VI, Item 225, 4th Paragraph) and benefits from legal protection established by federal legislation (see table for details).

Federal Legislation Relevant to Forest Protection

Law	Protection defined
Forest Code: (Law # 4,771/65, modified by Law # 7,803/89, and complemented by the Temporary Measure # 2166-67, of 08/24 /2002, and by the Resolutions CONAMA # 302 and 303, of 03/20/2002.)	▪ Permanently areas of land between 30 and 500 meters along rivers, springs, lakes and reservoirs as well as hillsides, mountain tops, mountains, and hills (2nd Chapter) ▪ Determines that 20 per cent of the rural properties in the Atlantic Forest biome must remain forested as a Legal Reserve
National Environmental Policy: (Law # 6,938/81)	▪ Gives forests and permanently preserved vegetation defined by the 2nd Chapter of Law 4,771 the status of reserve or ecological station
Environmental Crime Law: (Law # 9,605/98)	▪ Considers it a crime and determines penalties for those who destroy forests or cause damages to Conservation Units and Permanently Preserved Areas
National Water Resource Policies: (Law # 9,933/97, supplemented by Law # 9,984/00)	▪ Determines the integration of water resource management and environmental management ▪ Foresees the creation of area subject to use restrictions aiming to protect water resources ▪ Foresees incentives, including monetary compensations, for the qualitative and quantitative conservation of water resources
National System for Protected Areas – SNUC: (Law # 9,985/00)	▪ Imposes the SNUC and establishes norms for the creation, implementation, and management of protected natural areas

Source: MMA - Ministério do Meio Ambiente. Legislação ambiental brasileira. www.mma.gov.br, in July 2003.

In the following section the status and protection levels of the RJMA watershed and the wider river catchments are examined separately.

- **Protected areas of the RJMA Watersheds**
  The watersheds of Rio de Janeiro and the Metropolitan Area are located in four areas protected as Conservation Units (see table). These units are concentrated in six of the twelve municipalities of the RJMA and cover nearly 16 per cent of the total land area. Although they are protected by law, the implementation and monitoring of these areas is precarious, and there is considerable pressure on remnant forested areas and watersheds associated with uncontrolled urban expansion.

RJMA Conservation Units/Protected Areas

Status the protected area	Area (ha)	Location (municipality)	Characteristics/Objectives
Tijuca National Park: Category II (Created by Federal Decree # 50,923 of 07/06/61 and # 60,183 of 02/08/67. Decree 577, of 12/11/1861, gave "temporary instructions for planting and conserving Tijuca and Paineiras forests"[361]	3,200	Rio de Janeiro	Integral protection unit which includes three areas within the city of Rio de Janeiro, at an altitude of 80 and 100 m. Probably the world's largest urban forest. Has been the site of preservation and restoration since the 19th Century, to protect the city's water sources.
Tingua Biological Reserve: Category I (Created by Federal Decree # 97,780/89 on land belonging to the Florestas Protetoras da União de Tingua, Xerem e Mantiqueira, as a result of demands by community associations. Declared a Protection Forest in 1833 to protect watersheds, the first legal environmental defense action in the country.)	26,000	Duque de Caxias, Nova Iguassu, Miguel Pereira, and Petropolis	Integral protection unit composed of dense tropical rainforest, aiming to protect the Atlantic Rainforest, its flora and fauna, and the water resources of Sao Pedro, Rio d'Ouro, Xerem, Tingua and Mantiquira and springs of the rivers on the Guandu catchment.
Pedra Branca State Park: Category II (Created by Decree # 1,634/63 and Law # 2,377/74, encompassing the area of Florestas Protetoras da União instituted by the federal government in the beginning of the 20th Century.)	12,500	Rio de Janeiro	Integral protection units located above 100 m associated to the protection of water sources supplying Jacarepagua and Guaratiba.
Gericinó-Mendanha APA: Category V (Created by State Law # 1,331/88 and Municipal Law # 1,958/93. Floresta Protetora da União created by Decree/Law # 3,889/41.	10,500	Rio de Janeiro, Nova Iguassu, and Nilopolis	Sustainable use unit located above 100m. Protection of threatened Atlantic Rainforest fauna and flora, alkaline rocks and watersheds in Campo Grande and water sources of the rivers of the Guandu catchment.
Total (ha)	**52,200**		

Source: SEMADS (2001); Atlas das unidades de conservação da natureza do estado do Rio de Janeiro. Secretaria de Estado de Meio Ambiente e Desenvolvimento Sustentável do Rio de Janeiro. São Paulo: Editora Metalivros

- **Protection of the Paraiba do Sul River, Pirai, Lage and Guandu Catchments**
  Three distinct areas determine the condition of waters supplying the Guandu water treatment facility:

1. *The Paraiba do Sul River catchment and the Santa Cecilia reservoir*. The area covers almost 16,300 km^2 in the states of Sao Paulo (13,900 km^2, 39 municipalities, and nearly 1,850,000 inhabitants) and Rio de Janeiro (2,400 km^2, 8 municipalities, and nearly 650,000 inhabitants). There are several protected areas (see table) within this area, which protect the headwaters of the Paraiba do Sul River.
2. *Pirai and Guandu River catchment*: The Pirai River catchment area covers some 1,100 km^2 and has 38,000 inhabitants. Since most of its area is considered part of the Atlantic Rainforest Biosphere Reserve, there are no specific conservation units in this catchment. There has been a slight reduction in forest cover in the past decades[362]. The Guandu River catchment covers an estimated 1,000 km^2 and has 300,000 inhabitants. The area is degraded, and has no legal protection, aside from a few small stretches of Conservation Units.
3. *Contribution catchment for the Lages reservoir:* This area, covering approximately 300 km^2, has no Conservation Units, and is only protected under the regulations established by the Forest Code. However, forest cover in the catchment is much higher than either the Paraiba do Sul or the Pirai River catchments (see table). Its superior water quality and forest cover can be attributed to:
    - A one-kilometre wide marginal area along the reservoir owned by Light Energy Company. When the reservoir was built in 1908, a malaria outbreak killed hundreds of people. The company purchased land around the reservoir to act a buffer and thus reduce the exposure of residents to the disease. Since then, forest cover of these areas has continually increased;
    - These areas are steep and of difficult access, thus discouraging occupation; and
    - There are no cities or industrial activities in the catchment.

Protected Areas of the Paraiba do Sul River Catchment upstream from Santa Cecilia

Status of the Protected Area	Area (ha)	Location (municipalities)	Characteristics/ Objectives
Ecological Station: IUCN 1a			
1. Bananal Ecological Station (State Decree # 26,890, 03-12-87)	884	Bananal/SP	Located in the broadleaf altitudinal subtropical forest realm (Atlantic Forest).
Parks (National, State): IUCN II			
2. Itatiaia National Park (Created by Federal Decree # 1,713/37, first in Brazil)	30,000	Itatiaia and Resende/RJ; Alagoa, Bocaina de Minas and Itamonte/MG	Located in the shade-tolerant dense ('ombrófila densa') Atlantic Forest realm, with a highest peak of 2782 m.
3. Serra da Bocaina National Park (Decree # 68,172, of 02-04-71)	120,000	Ubatuba, São José do Barreiro and Cunha	Located in the shade-tolerant dense ('ombrófila densa') Atlantic Forest realm. The park includes the headwaters of streams that form the Paraiba do Sul river.
4.Serra do Mar State Park (State Decree # 10,251, de 08-30-77)	309,938	São Paulo, São Bernardo do Campo, Santos, São Vicente, Cubatão, Praia Grande, Pedro de Toledo, Itanhaém, Mongaguá, Peruíbe, São Luis do Paraitinga, Cunha, Caraguatatuba, São	Located in the shade-tolerant dense ('ombrófila densa') Atlantic Forest realm. The park includes the headwaters of the Paraibuna, a tributary of Paraiba do Sul.

Status of the Protected Area	Area (ha)	Location (municipalities)	Characteristics/ Objectives
		Sebastião, Paraibuna, Biritiba-Mirim, Salesópolis, Mogi das Cruzes, Suzano, Embu-Guaçu, Juquitiba, Santo André, Rio Grande da Serra, Natividade da Serra and Ubatuba	
Area of Relevant Ecological Interest: IUCN III			
5. Cicuta Forest (Decree 90,792 of 01/09/85)	131	Barra Mansa and Volta Redonda	
6. Arie da Pedra Branca (Decree SMA n.º 26.720/87 e Lei n.º 5.864/87)	635	Tremembé/SP	The area protects natural forests, the local fauna and water catchments.
Area under Special Protection Regime: IUCN IV			
7. ASPE de Roseira Velha (Resolution SMA/87)	84	Roseira (SP)	Protects rare fauna and flora species, within the Roseira Velha Municipal APA, in Fazenda Boa Vista
Environmental Protection Area: IUCN V			
8. APA Federal da Bacia do rio Paraíba do Sul (Created by Federal Decree 87.561/82)	-	-	Protects headwaters, mountain tops, slopes and valleys of the Mantiqueira range. However, the protected area has not been implemented yet.
9. APA Federal da Mantiqueira (Created by Federal Decree n.º 91.304/85)	150,000	Cruzeiro, Guartinguetá, Lavrinhas, Lorena, Pindamonhangaba, Piquete, Santo Antônio do Pinhal, Queluz (SP) e Itatiaia, Resende (RJ)	Protected landscape and sustainable use protected area located in the shade-tolerant dense ('ombrófila densa') Atlantic Forest realm. It protects the upper reaches of the Mantiqueira range, which in the local indigenous language means "the place where water springs".
10. APA Silveiras (Law # 4,100, of 06-20-84 – State and Municipal)	42,700	Silveiras (SP)	Protected landscape and sustainable use protected area located in the shade-tolerant mixed high montane forests ('ombrófila altomontana mista' in the Atlantic Forest realm. The area protects the headwaters of the Paraitinga river.
11. APA Municiapl do Banhado de São José dos Campos (Law # 2,792, de 01-10-84 – Municipal)	-	São José dos Campos (SP)	

Status of the Protected Area	Area (ha)	Location (municipalities)	Characteristics/ Objectives
12. APA Municipal da Roseira Velha (Law # 424, 11-25-83 – Municipal)	-	Roseira (SP)	
13. APA Municipal de Bananal (Law # 033, de 09-15-97 – Municipal)	33,000	Bananal (SP)	
14. APA Municipal da Serrinha do Alambari	-	Resende/RJ	Buffer zone of the Itatiaia National Park, which protects the headwaters of a number of tributaries of the Paraiba do Sul river.
Total area	320,180		
Biosphere Reserve			
Reserva da Biosfera da Mata Atlântica (UNESCO, 10/10/92)	79,215	Barra Mansa, Barra do Piraí, Itatiaia, Resende, Volta Redonda	All remnants of the Atlantic Rainforest, especially the Serra do Mar forest corridor.

Source: SEMADS/RJ, 2001; ANA, 2002 and Rambaldi, 2002.

Vegetation Cover and Soil Use in the Paraiba Do Sul and Pirai River Catchments

Land cover	Paraiba do Sul to Santa Cecilia		Pirai		Paraiba do Sul to Santa Cecilia and Pirai	
Main Types	**ha**	**%**	**ha**	**%**	**ha**	**%**
1. Dense Tropical Forest	215,300	13.2	31,264	28.4	246,564	14.2
2. Seasonally Deciduous Tropical Forest	16,836	1.0	5,512	5.0	22,348	1.3
Total Forests(1+2)	232,136	14.2	36,766	33.4	268,912	15.4
3. Secondary Forest	205,292	12.6	15,108	13.7	220,400	12.7
Total forest cover(1+2+3)	437,428	26.8	51,874	47.1	489,312	28.1
4. Field/pasture	970,444	59.5	55,380	50.3	1,025,824	58.9
5. Farm areas	66,332	4.1	0	0	66,332	3.8
6. Reforestation	64,476	4.0	1,388	1.3	65,864	3.8
7. Urban Areas	43,728	2.7	548	0.5	44,276	2.5
8. Other	48,860	3.0	816	0.7	49,676	2.9
Total	1,631,276	100	110,016	100	1,741,292	100
% of total area of the Paraiba do Sul Catchment (5,547,448 ha)	-	29.4	-	2.0	-	31.4

Source: data table of the PGRH-RE-029-R0, LABHIDRO-COPPE report (in Agência Nacional de Águas (2002); Projeto Gestão dos Recursos Hídricos da Bacia Hidrográfica do Rio Paraíba do Sul: PGRH-RE-029-R0 - Plano de Proteção de Mananciais e Sustentabilidade no Uso do Solo. Rio de Janeiro: Laboratório de Hidrologia e Estudos do Meio Ambiente da COPPE/UFRJ) accomplished through a GEROE mapping (1995) based on Landsat TM/ 1993-95 images.

Variation in Forest Cover: The Paraiba Do Sul and Piraí River Catchments and Lages Reservoir (State of Rio de Janeiro)

Catchment	1956/75*	2001**			Variation 1975/ 2001
	Forest Cover (%)	Original Forest (%)	Secondary Forest (%)	Total Forest Cover (%)	
Mid upper Paraiba do Sul River (only RJ state)	15.44	5.84	15.23	21.07	+ 5.63 (+36.5%)
Pirai River	41.31	5.94	33.94	39.88	- 1.43 (-3.5%)
Lages Reservoir – estimated (data from the Rio Claro municipality)	43.52	10.06	37.64	47.70	+ 4.18 (+9.6)

Source: * IBGE, from aerial photos in black and white taken between 1956 and 1975; ** Soil Use Map from the CIDE Foundation from Landsat TM/2001 images

Note: When comparing information on forest cover along the Pirai catchment in the two tables above there is a clear discrepancy between the sources used, research to ascertain which source is correct is beyond the scope of this project.

Conclusions

Historically, Rio de Janeiro had a good record of protecting the watersheds that provided water to its population. However, as newer water facilities were developed the importance of forests in protecting, in particular, water quality seems to have been forgotten as chemical water treatments became available. This case study shows, however, that where forests have been protected water quality standards remained high and the water treatment is much reduced.

As the economics of providing safe water to Rio de Janeiro, along with questions of maintaining an adequate water supplies, come to the forefront the Committees for the Paraiba do Sul and Guandu River catchments, legal entities, water consumers, the public administration and civil organisations should be encouraged to develop integrated planning arrangements that recognise the needed for investment, waste reduction, rationing and environmental conservation to ensure the future water supply in for the city and surrounding area.

The declaration of the Atlantic Rainforest Biosphere Reserve in 1991 provides a vehicle for the protection of the forests and the city's water catchment areas, however, much more work is needed to ensure that the existing protected areas are implemented and managed effectively, and their borders consolidated against urban encroachment and land speculation.

Part 5: Conclusions and policy recommendations

Our research shows that many cities are reliant on protected forests for their drinking water. A clear understanding of the links between watersheds and water supply can encourage management decisions with benefits for biodiversity, for people in cities and, through compensation schemes, for people in the catchment. None of these links is simple. The hydrological processes are complex and the results of their interactions with precipitation inputs and land-use will vary from one place to another: management decisions based on incomplete understanding may do little good or actual harm. Careless protection can undermine the rights of the rural poor living in the catchment. Good catchment management will only benefit urban dwellers if treatment and distribution of water are also effective. The links between water, protected areas, livelihoods and biodiversity conservation will only be optimised if management is carefully planned and negotiated with all relevant stakeholders. Below we suggest some responses that might help to maximise the gains.

- **Awareness-raising**: we were surprised about how hard it was to find information for this report. Even in cities where water comes from protected areas, or other forms of active management, this seldom features in reports, publicity or websites. Many people have no idea where their tap-water comes from. Yet where there has been a debate and an information campaign – as in New York City – support for catchment management is high. Better information about links between forests, protected areas and water supply could help build a constituency for good watershed management.

- **Protection**: protected areas are not a panacea, but they are clearly an important option to help to secure urban water supplies. We found several instances where lack of protection has been already been identified as a problem and other cities where it seemed that better catchment management would help to address urgent problems in quality and in some cases also of supply. Increased use of protection, including protected areas, could help many cities to maintain their drinking water.

- **Landscape approach**: protection is also not the only or always the most appropriate action. In crowded areas, or where existing land use and tenure makes full protection inappropriate, other approaches exist including management and restoration, which can for instance result in a mosaic ranging from full protection to a number of carefully chosen management interventions.

- **Livelihoods**: care is needed to ensure that politically powerful urban populations do not gain high quality water at the expense of rural communities. Approaches that include negotiation, joint decision-making and compensation, including payments for environmental services, have proved to be the most successful in ensuring equity.

- **Economics**: experience shows that with the right set of circumstances, it pays to protect the watershed, instead of building expensive water purification systems. In the context of growing population and increasing urbanisation, strategic choices are needed now to set aside funds not only for protection but for effective management of forests and other vegetation.

- **Biodiversity**: protection of forests for their watershed values has important and usually beneficial implications for biodiversity. But we also found that in many cases these links had hardly been made and for example water companies were not really aware of the additional benefits that might be coming from their land management. Better understanding of biodiversity issues is required within water supply companies to make the best use of land set aside for water supply.

The World Bank-WWF Alliance is in an ideal position to encourage joint approaches by engineers, water companies, communities and conservation interests to ensure that well-managed natural vegetation plays a key role in ensuring access to a safe, secure source of drinking water.

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WORLD BANK/WWF ALLIANCE

Email: wbwwfalliance@worldbank.org
Internet: www.forest-alliance.org

WWF International

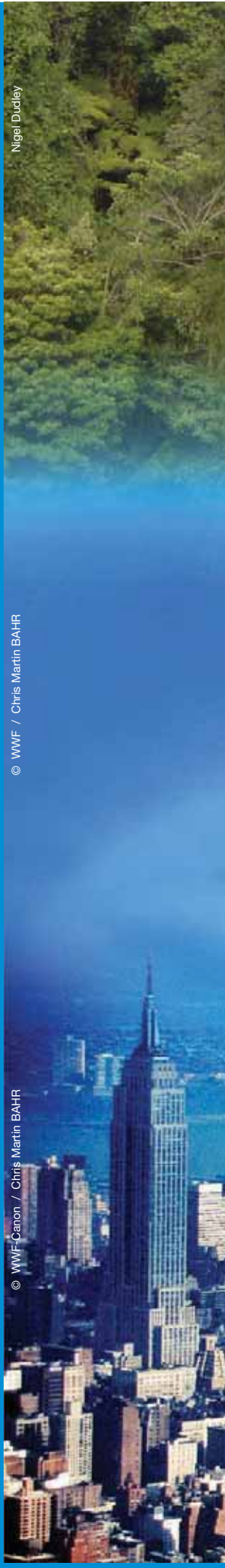
Ave. du Mont Blanc
CH-1196 Gland
Switzerland

Telephone: +41 22 364 9111
Fax: +41 22 364 0640
Internet: www.panda.org

The World Bank

1818 H Street, N.W.
Washington D.C. 20433
U.S.A.

Telephone: +1 202 473 1000
Fax: +1 202 522 1142
Internet: www.worldbank.org



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Nigel Dudley

Water Protection Series

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AMERICAN WATER WORKS ASSOCIATION

"The health of our waters is the principal measure of how we live on the land."

LAND CONSERVATION AND THE FUTURE OF AMERICA'S DRINKING WATER

PROTECTING THE SOURCE

THE TRUST *for* PUBLIC LAND
CONSERVING LAND FOR PEOPLE

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The Trust for Public Land conserves land for people to enjoy as parks, gardens, and other natural places, ensuring livable communities for generations to come.

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AWWA is the authoritative resource for knowledge, information, and advocacy to improve the quality and supply of drinking water in North America and beyond. AWWA is the largest organization of water professionals in the world. AWWA advances public health, safety, and welfare by uniting the efforts of the full spectrum of the drinking water community. Through our collective strength we become better stewards of water for the greatest good of the people and the environment.

Written by Caryn Ernst
Edited by Kim Hopper and David Summers

Quotation on front cover by Luna Leopold, professor emeritus, Department of Landscape Architecture, University of California, Berkeley

LEFT COVER PHOTO:

Protecting watershed land has many benefits. In Ohio, just south of Lake Erie, Edison Woods offers public access to 1,300 acres of woods, wetlands, and meadows.

RIGHT COVER PHOTO:

More than half a million people receive their drinking water from Mountain Island Lake near Charlotte, North Carolina.

PROTECTING THE SOURCE

Land Conservation and the Future of America's Drinking Water

THE TRUST *for* PUBLIC LAND
CONSERVING LAND FOR PEOPLE

THIS REPORT WAS PRODUCED
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Henry Phillip Kraft Family Memorial Fund
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Aquarion Water Company

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Will Rogers

COURTESY OF AMERICAN WATER WORKS ASSOCIATION

Jack Hoffbuhr

In 1997, the Trust for Public Land (TPL) released the first edition of *Protecting the Source*. The report promoted the strong interrelationship between land and water resources and the absolute necessity of landuse planning in watershed management. Over 15,000 copies of the report were distributed to communities across the country. This new edition of *Protecting the Source* is the result of a partnership between TPL and the American Water Works Association (AWWA) to look more closely at the case for land conservation as a source water protection strategy.

The release of the 1997 report coincided with the 1996 amendments to the Safe Drinking Water Act that mandated a state source water assessment and planning process—and, we think, created a renewed interest in a multiple-barrier approach to source protection. By the mid-1990s, TPL was increasingly working with local governments and water suppliers on land conservation strategies for water quality protection. Based on public surveys testing voter support for new taxes to support land conservation, it was clear to us by the late 1990s that the public was greatly interested in using land conservation as a tool to address water quality.

In 2002, TPL formed a partnership with AWWA to revisit the ideas in the first edition of *Protecting the Source* and to provide a stronger case and a set of best practices for using land conservation for source protection. AWWA's Source Protection Committee, composed of volunteer practitioners and scientists, has worked diligently to support TPL's efforts to ferret out research and field practice regarding the value and practice of land conservation for protecting drinking water quality.

AWWA has long promoted the idea of source protection. Reporting on the results of a major 1991 AWWA Research Foundation watershed management study, the *AWWA Journal* asserted that "the most effective way to ensure the long-term protection of water supplies is through land ownership by the water supplier and its cooperative public jurisdictions." At that time, the *Journal* noted, the median percentage of watershed lands owned by water utilities nationwide was only 2 percent. That number has not changed significantly over the past decade.

TPL and AWWA's partnership on this edition represents the first effort in a collaboration to promote suppliers' ability to turn EPA-mandated source water assessments into protection strategies. Both organizations are strongly committed to source protection. In the summer of 2003, AWWA's board reaffirmed its commitment to securing drinking water from the highest quality sources available and to "actively and aggressively" protecting those sources. Land conservation is central to TPL's mission, and over 30 years of partnering with local and state governments on land protection strategies make it well suited to partnerships with water suppliers.

The original edition of *Protecting the Source* introduced the issue of source protection to landuse planners—and revisited historical efforts. It highlighted the increasing pressure on supplies as development sprawls into drinking watersheds. This new edition builds on earlier case-making with more detailed information on cost benefits, on the increasing challenges to water treatment, and on a growing body of knowledge regarding the use of land conservation for source protection.

For 60 years, the safety of most of America's drinking water has been dependent on technology. Today, water suppliers are revisiting the idea that watershed protection—the first barrier against contamination—needs to, once again, be an integral part of their water quality protection strategy. The information and best practices in this report will ensure that suppliers will be well prepared to take on this challenge.

Will Rogers
President
TPL

Jack W. Hoffbuhr
Executive Director
AWWA

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TPL's Source Water Protection Advisory Committee

Scott Abrahamson, New York State, Department of Environmental Conservation
Paul Barten, University of Massachusetts
Kathy Blaha, Trust for Public Land
Suzanne Chiavari, American Water
Chris Crockett, Philadelphia Water Department
Scott Emry, Hampton Roads Planning District Commission
Stephen Gasteyer, Rural Community Assistance Program
Richard Gullick, American Water
Ed Holland, Orange Water and Sewer Authority, North Carolina
Pam Kenel, Black and Veatch
Gary Logsdon, Black and Veatch
Walton Low, U.S. Geologic Survey, National Water Quality Assessment Program
Kirk Nixon, San Antonio Water System
K. C. Price, Startex, Jackson, Wellford and Duncan (SJWD) Water District
Grantley Pyke, Hazen and Sawyer
Carol Storms, New Jersey American Water Company
Brian Thompson, Aquarion Water Company of Connecticut

TPL would also like to thank the many water suppliers who participated in our survey, which surfaced critical information on the link between forest cover and treatment costs. We would like to convey our special appreciation to the many municipalities, water utilities, and state and federal agency representatives who provided extensive materials for our case studies and background data for making the case. EPA staff at the Office of Ground Water and Drinking Water, especially Debra Gutenson, supported TPL's fieldwork, where many of our best practices and case studies originated. We are grateful for their partnership and support of our work.

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EXECUTIVE SUMMARY

Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land.

—Luna Leopold

In 1896, shortly after constructing its first public water supply system, Seattle leaders agreed on a long-term plan to eventually own the entire Cedar River Watershed, thus permanently protecting and securing Seattle's drinking water source. With a 100,000-acre watershed, it was a bold vision.

One hundred years later, Seattle's original vision had finally been achieved. By taking advantage of opportunities, creating dedicated local funding, and patiently sticking to a long-term vision, the City of Seattle has permanently protected one of the most pristine sources of drinking water in the country. Seattle made a cost-effective investment in clean source waters that will never be threatened by pollution from roads, sewers, or urban runoff. It is an investment that will continue to pay off many times over through reduced treatment costs and a safe supply of water for generations to come.

Unfortunately, watersheds in many other fast-growing communities remain unprotected and threatened by development. New roads, homes, and commercial development can abruptly alter a landscape and generate nonpoint source pollution that contaminates drinking water supplies. According to the U.S. Environmental Protection Agency, the leading cause of water quality degradation is nonpoint source pollution (NPS)—over 60 percent of pollution in U.S. waterways comes from runoff from lawns, farms, cities, and highways, as well as leachate from rural septic systems and landfills. While point sources of pollution—which emit from pipes, canals, or municipal wastewater treatment plants and industrial facilities—have been closely monitored and regulated since the 1970s, the management of nonpoint sources of pollution has only recently become a national priority.[1]

Advances in treatment technologies allow most suppliers to meet current drinking water standards, yet the constantly expanding diversity of contaminants, coupled with greater pollutant loads and fewer natural barriers, has made treatment more difficult and expensive, and it has increased the chances that contaminants will reach our tap. Some of the treatment challenges faced by suppliers drawing from intensively used source lands include:

1. The emergence of new contaminants that suppliers may not be prepared to test or treat
2. Spikes in contaminant loads due to storms and flooding that make treatment more challenging
3. Constantly changing standards and regulations regarding new contaminants, which are present in the water long before they are identified as threats to public health
4. Increased treatment and capital costs due to higher pollutant loads and changing water quality standards

The loss of natural lands to development impacts not only the quality of our drinking water, and therefore the cost of treating it, but also the *quantity*. That's because development increases demand for drinking water while decreasing the ability of water to infiltrate the ground and recharge water supplies. Sprawling suburban-style development contributes even more to water scarcity than does compact development, as it promotes more lawn areas and larger lots planted with turf grass, requiring significantly more water than homes with smaller lots.

Watershed Management—The First Barrier in a Multiple-Barrier Approach to Source Water Protection

The considerable threats to our drinking water require an integrated and comprehensive response. Governments and water suppliers are tasked with protecting each droplet of water. Starting in the watershed or aquifer recharge areas, continuing through the treatment process, and extending to the distribution system, suppli-

© KEN SHERMAN

The Geauga Park District acquired 574-acre Bass Lake Preserve at the headwaters of the Chagrin River, 25 miles east of Cleveland, Ohio, in 2003 to help protect regional water quality. Watershed protection funds from the Ohio Environmental Protection Agency made the transaction possible.

ers must safeguard the water from contamination, erecting multiple barriers of protection at every stage from source to tap. It is a *multiple-barrier approach*; each method of protection acts as a barrier safeguarding water from contamination.

Watershed protection is the first and most fundamental step in a multiple-barrier approach to protecting drinking water. Healthy, functioning watersheds naturally filter pollutants and moderate water quantity by slowing surface runoff and increasing the infiltration of water into the soil. The result is less flooding and soil erosion, cleaner water downstream, and greater groundwater reserves.

When communities invest in land protection as a way to protect their drinking water, they are investing in the long-term health and quality of life of their citizens—guiding growth away from sensitive water resources, providing new park and recreational opportunities, protecting farmland and natural habitats, and preserving historic landscapes. Many communities don't realize the cost-saving benefit of source protection and the potentially dramatic increase in treatment costs that can result from the loss of forests, grasslands, and wetlands, and the natural filtration these landscapes provide. A study of 27 water suppliers conducted by the Trust for Public Land and the American Water Works Association in 2002 found that more forest cover in a watershed results in lower treatment costs. According to the study, for every 10 percent increase in forest cover in the source area, treatment and chemical costs *decreased* approximately 20 percent, and approximately 50 to 55 percent of the variation in treatment costs can be explained by the percentage of forest cover in the source area.[2]

This report presents a series of best practices to guide communities' source protection efforts and to showcase those communities that are already linking land and water protection effectively. *Protecting the Source* serves as a reference and resource for those seeking best practices in developing and maintaining the highest level of water quality and, at the same time, preserving our limited natural land resources.

Best Practices— Guiding Implementation in the Field

The following five best practices provide a framework for developing and implementing a source protection plan for city planners, government officials, and water suppliers.

1. *Understand your watershed*: An effective source protection plan is built upon an understanding of your watershed and aquifer recharge areas. Scientific data and watershed analyses are essential to define an effective source protection plan and build public support for its implementation.
2. *Use maps and models to prioritize protection*: Municipal water supply managers and conservation agencies routinely face questions and problems when choosing where to invest in conservation and restoration strategies. Using maps and models to identify high-priority land for protection and restoration is critical, as funding is always limited and multiple demands are often made upon a valuable piece of land.
3. *Build strong partnerships and work watershed-wide*: The support and cooperation of a variety of public and private partners will be required to effectively implement a source protection plan, as most communities' source areas lie partially, if not entirely, outside of their jurisdiction. Effective source water protection can be achieved by influencing others to act on your behalf, utilizing existing initiatives and frameworks, and finding common goals with others.[3]
4. *Create a comprehensive source protection plan*: Creating a comprehensive source water protection plan is an opportunity to pull together everything learned from analyzing a watershed, assessing the threats to drinking water, mapping high-priority land for protection and restoration, and developing partnerships. Such a plan should incorporate:
   - Strategies for both managing threats and protecting natural resources
   - A combination of voluntary and regulatory strategies
   - A long-term vision, short-term action strategies, and measurable goals
   - A strategy to fund the plan
5. *Develop and implement a "funding quilt"*: Implementing a comprehensive source water protection plan requires a significant and steady stream of funds. Successful communities secure funds from a variety of sources—federal, state, local, and private—creating a "funding quilt." By tapping into a range of sources, communities can raise and leverage significant amounts of money and avoid reliance on a single revenue stream.

Moving Forward

The 1996 amendments to the Safe Drinking Water Act reflected a renewed national focus on source protection as a tool to prevent the contamination of drinking water supplies. Instead of focusing on water treatment, emphasis is placed on contamination prevention and on the integrated management of source areas by requiring all states to develop Source Water Assessment Plans (SWAPs), which identify threats to every public water supply in the state. These forward-thinking amendments mark a return to a set of historic best practices in watershed protection and management.

Local water suppliers support the notion that watershed planning and protection activities are key to a multiple-barrier approach. Voters support it too, with poll after poll showing support for new taxes for land conservation that protects water quality. States are also creating programs and using federal Clean Water Act dollars more creatively to support more comprehensive approaches to addressing threats from nonpoint source pollution. State and federal support, through increased and more flexible funding options, new tools and technologies, and incentives to promote the creative use of existing programs, will be key in ensuring their success.

With the completion of the Source Water Assessment Plans, local communities are poised to move forward on implementing source protection strategies. The best practices outlined here offer a guide to success for local communities.

PART ONE

MAKING THE CASE

Protecting Water Resources

As we grow, the land around us changes forever. Sometimes this happens dramatically as new roads, homes, and commercial development abruptly alter our landscape. Other times it is subtle, and we recognize that we've lost farmland, forestland, and open space over the years.

The numbers confirm the story. Urbanized land—land with houses, businesses, or industry—has quadrupled since 1954. From 1992 to 1997, the national rate of land development more than doubled to three million acres per year, and urban land area increased more than twice as fast as did population between 1950 and 1990.[4] These changes impact our communities, our quality of life, and our natural resources—the air and water we need to survive.

Increased sprawl and development brings increased pressure to develop land in drinking water source areas. Once development infringes on source areas, the controls designed to protect water quality become stressed. Although advances in treatment technologies allow most suppliers to meet current drinking water standards, the challenges of storm water runoff from agricultural and developed lands make treatment more heavy-handed, complex, and expensive. Compounding the problem is the loss of wetlands, forestlands, and grasslands, which naturally filter water and serve as buffers to water supplies.[5]

The considerable threats to our drinking water require an integrated and comprehensive response. Consider for a moment that a drop of water often traverses many miles through both natural and manmade systems before reaching household drinking taps. Governments and water suppliers are tasked with protecting this droplet during its travels—beginning in the watershed or aquifer recharge area, continuing at the treatment facility, and extending through the distribution system—ensuring the purity of each glass of drinking water poured by the consumer. The process is a *multiple-barrier approach*; each method of protection acts as a barrier safeguarding water from contamination.

Considering the water droplet's journey, the first opportunity to protect it from contaminants is at its source—the point at which water falls to earth, either seeping into the ground and into underground aquifers, or winding its way across the earth through surface waterways. The reservoir or waterway itself is the next protection point. Then, barriers are needed to remove impurities as the water is processed in treatment plants and flows into canals, pipes, wells, and holding tanks, and finally to the tap.

Historically, protecting source lands—the watersheds that supply surface water and the aquifer recharge areas that cover groundwater sources—has been an essential part of a multiple-barrier approach to clean drinking water. Cities such as Seattle, San Francisco, Boston, and New York initiated source water protection efforts in the 1800s as a primary tool for protecting public health before chlorination and other treatment technologies were available. Understanding the value of a protected source, they continue to employ source protection methods today.

Many newly developing midsize cities and suburbs have not been as proactive about protecting their source areas. "Authorities face tough choices between building houses for growing populations, chopping down forests for timber, or conserving them to help secure the water supply," say Chris Elliot, Director of World Wildlife Fund's Forest for Life Program.

Fortunately, source protection is receiving a renewed focus. With the passage of the Safe Drinking Water Act, Congress and the U.S. EPA emphasized the protection of source waters as a key component of our national efforts to safeguard America's drinking water. It is increasingly clear to many at the federal, state, and local levels that land conservation and watershed management practices are necessary to reduce pollutant loads to aquifers, rivers, and reservoirs in our complex watersheds.

This report makes a case for land conservation as an essential element of the multiple-barrier approach to water protection. It does so by presenting a series of best practices to guide communities' efforts in the field, and by highlighting those communities that already link their land and

water protection efforts. *Protecting the Source* serves as a reference and resource for those seeking best practices in protecting their precious water resources and preserving their sensitive natural lands.

The Trust for Public Land has also produced a companion report, *Source Protection Handbook: Using Land Conservation to Protect Drinking Water Supplies*, which provides detailed guidance on how to implement each of the best practices presented in *Protecting the Source.* Copies of the handbook can be ordered from TPL's Web site, *www.tpl.org*.

Despite the expenditure of hundreds of billions of dollars over the last 30 years, the 1972 Clean Water Act goals of fishable and swimmable waters have not been achieved, largely because contaminants from diffuse [nonpoint] sources have not been controlled successfully.

National Research Council, 2001[6]

Nonpoint Source Pollution—The Primary Threat

Point sources of pollution—which emit from pipes, canals, or municipal wastewater treatment plants and industrial facilities—have been closely monitored and regulated since the 1970s, but the management of nonpoint sources of pollution (NPS) has only recently become a national priority.[7] NPS pollution includes runoff from lawns, farms, forests, cities, and highways, as well as leachate from rural septic systems and landfills. As water from rainfall or snowmelt flows over the ground, it carries with it natural and human-made pollutants. Eventually, these pollutants reach our lakes, rivers, oceans, and even underground sources of drinking water, as they seep into the ground.

According to the U.S. Environmental Protection Agency, the leading cause of source water degradation is nonpoint source pollution.[8] Although agriculture is currently the greatest nonpoint source threat to drinking water quality, urban runoff is the fastest-growing threat nationwide. The development of formerly forested land can also exacerbate existing agricultural pollution, for it removes the natural buffers that once trapped and filtered those pollutants before they reached waterways. In Carroll County, Georgia, Commission Chairman Robert Barr has seen that change firsthand. "In our county there has been a rapid shift from agricultural landuse to suburban landuse," explains Barr. "Row crops are no longer a major landuse. The greatest new contributor to water quality degradation is accelerating residential and commercial development."

The impact of NPS on the quality of un-

CLEAN WATER ACT AND SAFE DRINKING WATER ACT

Congress passed mandates for drinking water protection in the 1980s that form the basis for modern water protection activities. Although these laws focus on mitigating existing pollution and constructing or upgrading wastewater and drinking water treatment plants, the Clean Water Act and Safe Drinking Water Act can potentially fund initiatives focused on protecting source waters via land conservation.

Clean Water Act: The goal of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters so that they can support the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water. Under the Clean Water Act, the EPA funds three water quality programs:[9]

- *Clean Water State Revolving Fund (SRF) (Section 212):* Provides loans for water quality improvements and has traditionally been used for wastewater treatment infrastructure, but it can also be used to fund the implementation of nonpoint source management plans and the development and implementation of estuary plans. In 2003, states were awarded $1.29 billion and provided $4.7 billion in assistance for wastewater, nonpoint source, and estuary projects. Currently, only about 5 percent of the Clean Water SRFs are used for mitigating nonpoint source pollution, with 95 percent going toward wastewater treatment infrastructure.[10]
- *Nonpoint Source Program (Section 319):* Provides grants for projects that address nonpoint source pollution, such as implementation of best management practices, restoration, and public education. Approximately $237.5 million in grants was distributed for this program in 2002. The Nonpoint Source Program receives only 17 percent of clean water funding, despite the fact that NPS pollution now accounts for 60 percent of all pollution in U.S. waterways.[11]
- *National Estuary Program (Section 320):* Funds projects that protect or improve estuaries. The program distributed $17 million in 2002.

Safe Drinking Water Act: Under the Safe Drinking Water Act, the EPA awards grants to states to fund Drinking Water State Revolving Funds (DWSRFs). State Revolving Funds provide eligible public water systems with loans and other assistance to finance infrastructure projects. Up to 31 percent of these capitalization grants can be set aside to administer the SRFs and state source protection programs and to fund source water protection activities, including land acquisition. Up to 15 percent of the set-aside can be used for land conservation and voluntary, incentive-based protection measures, with no more than 10 percent used for a single type of activity, such as land protection. In 2003, states were awarded $787.4 million and were provided $1.3 billion in loans for infrastructure improvements. Since the act's inception, only $2.7 million in assistance has been used by systems to protect less than 2,000 acres of land under the set-asides.[12]

treated water depends on several factors, including the amount of pollutants carried by runoff (pollutant load) and the pathway the water takes when it flows through the source area. If water flows quickly over the surface of the land, most of the pollutants it carries will reach the main body of water. If the water flows more slowly or infiltrates the ground, more of the pollutants will be filtered out, either by adhering to plants and soil or by being absorbed through plants' root systems. Pollutants are carried between surface water and groundwater, which means that both resources must be monitored and protected.

Water resource protection requires an understanding of the interconnection between groundwater and surface water. The terms "surface water" and "groundwater" refer to the same water regardless of its source. They merely clarify the location of the water at a particular time.[13] According to a national study performed by the U.S. Geologic Survey, an average of 52 percent of stream flow nationally is provided by groundwater. The groundwater contribution can vary tremendously depending on the season and watershed characteristics, but the important point is that groundwater pollution, chemistry, and flow can directly impact surface water quality, as surface water pollution can impact groundwater quality. In areas where supply wells are located in shallow aquifers adjacent to streams or lakes, supply wells can reverse the direction of groundwater flow under pumping conditions, and they can induce aquifer infiltration through stream and lake bottoms.

The close relationship between ground and surface water makes it imperative that water suppliers understand what percentage of their supply comes from each in dry and wet seasons, and that they act to protect those resources. A closer look at just how ground and surface water sources are impacted by nonpoint source pollution follows.

Surface Water and Nonpoint Source Pollution

Surface water is precipitation that does not infiltrate the soil. Instead, the water moves as overland flow to streams and rivers. The land area from which water drains into a surface water supply—a stream, reservoir, or lake—is called a watershed. In a watershed with natural groundcover, about 50 percent of precipitation infiltrates the ground and only about 10 percent flows over the land surface as runoff. In a highly developed watershed, with its impervious surfaces and lack of vegetation, about 15 percent infiltrates and approximately 55 percent becomes surface runoff, carrying sediment and pollutants to surface water bodies.[14]

The riparian zone is the area where streams interact with the land, and it is a stream's best defense for keeping nonpoint source pollutants out of its waters. The riparian zone protects water quality by processing nutrients, filtering contaminants from surface runoff, absorbing and gradually releasing floodwaters, maintaining fish and wildlife habitats, recharging groundwater, and maintaining stream flows.[15]

Groundwater and Nonpoint Source Pollution

Water moves underground through pores in the soil and cracks in surface rocks. An *aquifer* is rock or soil that contains and transmits water and thus can be a source of underground water.[16] In a confined aquifer, layers of impermeable clay or rock, above and below the aquifer, protect the water from some contaminants and restrict the water's movement. The recharge area for a confined aquifer, where surface water infiltrates the land and resupplies the aquifer, may be miles from a well that draws water from it.

In an unconfined aquifer, water can infiltrate directly from the surface to the aquifer, carrying landuse contaminants with it. The extent to

SOURCE WATER ASSESSMENT PROGRAMS

In 1996 the Safe Drinking Water Act (SDWA) was amended, placing a new focus on source water protection. The law requires every state to examine existing and potential threats to the quality of all public water supplies and to develop a Source Water Assessment Program (SWAP). The assessments' purpose is to inform and motivate local source water protection activities, which the EPA considers the critical initial component in the SDWA multiple-barrier protective scheme. Instead of focusing on water treatment, the amendment emphasizes contamination prevention and the integrated management of multiple supplies that share one source area.

As part of the U.S. Environmental Protection Agency's requirement that states conduct source water assessments on all source areas within their jurisdiction, states have identified all of the source areas that supply public tap water, inventoried potential contaminants, and assessed susceptibility to contamination. At the completion of the SWAPs, states must inform the public of the results. Although some resources were provided to the states to conduct assessments, no resources were authorized or appropriated for implementing protection strategies, and no mandate that it occur has been given. Implementation will have to be locally driven and creatively funded. Contact your local water supplier or your state source water protection office for more information and for a copy of the SWAP for your water supply. Contact information for state source protection offices can be found at http://www.epa.gov/safewater/protect/contacts.html.

which contaminants are filtered from groundwater as it passes through the soil depends on how porous the soil is. Where the soil is sandy or porous, water flows more quickly below the surface, and fewer contaminants are removed.

Reservoirs, lakes, aquifers, and other standing bodies of water tend to act as sinks for contaminants. When these water supplies are damaged, useable water resources are lost.[17] Some communities already connect more than one potential source to their treatment facility so as to choose which source to use at a particular time, depending on shifts in source water quality and the ability to treat substances in the water. In extreme cases, drinking water sources must be abandoned because water quality has become unsafe or too costly to treat, causing communities to invest tremendous resources in developing new sources. Wetlands and forested land, if left undeveloped, can help slow and filter water before it gets to lakes, rivers, and aquifers, keeping these drinking water sources cleaner and making treatment cheaper.

DRINKING WATER TREATMENT

Drinking water treatment is one of the most critical barriers in a multiple-barrier approach, as it provides a direct barrier against disease agents and is considered essential in protecting public health. Whether drinking water comes from groundwater sources or surface water supplies, it is likely treated before it reaches the tap. Even in the most pristine watersheds, natural pollutants such as animal waste and organic matter can impair the quality of water.

Modern drinking water treatment can reduce most source water contaminants to acceptable levels before water is delivered to consumers. The types of treatment necessary depend on the quality of the source water and the pollutants encountered. Water quality standards are created by the U.S. Environmental Protection Agency based on extensive public health research. These standards guide the amount and type of treatment needed for all ground and surface water supplies.

A wide variety of treatment methods are currently in use, and new technologies are employed regularly to ensure drinking water meets current standards. Treatment costs can increase significantly when more rigorous treatment is needed to cleanse contaminated source water.[18]

Most suppliers of surface water clarify the water through a sedimentation process (letting particles settle out), then filter water through sand or high-tech membranes in order to remove particles and microorganisms. Some facilities treat water with carbon or mix it with air to remove pollutants or reduce taste and odor. The final treatment state is disinfection, often using chlorine, to kill disease-causing microorganisms. All surface water supplies must be disinfected, although a small number of highly protected supplies are not required to be filtered. Many groundwater supplies are disinfected, though some are used without any treatment. For more information on how drinking water is treated or on treatment standards, go to www.epa.gov/safewater/DWH/Treat/.html.

CASE STUDY

Suffolk County, New York

Located at the eastern end of Long Island, Suffolk County contains much of New York's premier ecosystem, the Pine Barrens, underneath which is the island's largest supply of fresh drinking water. Suffolk County Water Authority is the largest groundwater supplier in the nation, serving 1.2 million residents from this federally designated sole source aquifer. Heavy development in the aquifer recharge area in recent decades led to concern about damage to this sensitive and unique ecosystem and the threat of nonpoint source pollution seeping into the groundwater.

In response to this concern, in 1987 Suffolk County voters overwhelmingly approved (83 percent to 17 percent) the continuation of a quarter-cent of the county's sales tax to purchase critical watershed areas through a new Drinking Water Protection Program. As part of this program, the county acquired watershed lands in one of the Special Groundwater Protection Areas (SGPAs); seven SGPAs are designated within the deep aquifer recharge areas of the county. Since the inception of the program, over $220 million has been spent on land acquisitions. When the program was due to expire in 2000, voters once again voiced their support for drinking water protection by extending the program through December 2013. By leveraging funding from their sales tax, Suffolk County also received a $75 million loan in the late 1990s and another $62 million in 2003 from New York's Clean Water State Revolving Fund to acquire land in priority watershed and aquifer recharge areas.

In the early 1990s, even as voters were approving the use of sales tax revenues to protect the Pine Barrens, several hundred development projects were being proposed in the central Pine Barrens. If these projects had been successful, the ecological integrity of the Long Island Pine Barrens would have been severely compromised. A grassroots advocacy effort by the Long Island Pine Barrens Society to educate the public and elected officials about the ongoing threats to the Pine Barrens led to the passage of the Long Island Pine Barrens Protection Act in 1993.

The legislation established a Central Pine Barrens Commission to oversee the development and implementation of a Comprehensive Management Plan (CMP). The plan delineated two major regions within the 100,000-acre area—a 52,000-acre core preservation area where no new development is permitted and

a 48,000-acre compatible growth area where limited, environmentally compatible development is allowed. The CMP also recommended that 75 percent of the core preservation area be preserved through public acquisition. The plan was adopted by the Pine Barrens Commission in 1995. Various landuse and zoning tools are used to accomplish the preservation goals of the act, including transfer of development rights, cluster zoning, and conservation easements.

CONTACT: Tom Isles, Planning Director
ADDRESS: Suffolk County, 100 Veterans Highway, Havtiange, NY 11788-0099
PHONE: 631-853-5190
FAX: 631-853-4044
EMAIL: Tom.Isles@co.suffolk.ny.us

CASE STUDY

Charlotte-Mecklenburg County, North Carolina

Mountain Island Lake (MIL), a section of the Upper Catawba River that has been shaped by a series of dams, is a meandering lake that divides Charlotte-Mecklenburg County from Gaston and Lincoln Counties in the southern piedmont of North Carolina. Although it receives some of its flow from Lake Norman, to its north, it receives most of its flow and pollutants from the Mountain Island Lake Watershed, a 69-square-mile watershed of which 72 percent lies in Charlotte-Mecklenburg County. The lake supplies drinking water to about 600,000 people in Charlotte-Mecklenburg County and in Gastonia and Mount Holly, both in Gaston County.

In the past decade, rapid development in the MIL Watershed raised alarms with local leaders, who feared that what they had taken for granted for so many years—clean water from Mountain Island Lake—was threatened by increasing sediment and fecal coliform from new development. In 1997, in response to this growing concern, the Foundation for the Carolinas convened a group of partners to create and implement a plan to protect the MIL Watershed, which became known as the Mountain Island Lake Initiative. The initiative's formation coincided with the state's creation of the North Carolina Clean Water Management Trust Fund (CWMTF), the first state-funded program in the nation dedicated to funding activities to protect and improve waterways statewide. The CWMTF's first grant was $6 million for the MIL Initiative's effort to protect a large tract on the western shore of the lake.

To ensure that future investments in the protection of MIL had the greatest impact on clean water, the MIL Initiative created GIS models of the watershed to help them identify the highest priority areas for conservation. Modeling showed that although protection of the lakeshore and regulated floodplain was important, protection of the smaller streams and tributaries in the headwaters was equally important. As a result, the MIL Initiative set a goal to protect both 80 percent of the lakeshore and 80 percent of its tributaries. In 1999 Charlotte-Mecklenburg County passed a $220 million land-banking bond to preserve land countywide for future public needs, including open space, parks, greenways, and schools. Fifteen million dollars of the bonds were directed to preserve land within the MIL Watershed. Over the next few years, the City of Gastonia, the City of Charlotte, and the North Carolina CWMTF also contributed funds to support land protection in the MIL Watershed. These years of focused protection efforts have protected 74 percent of the lakeshore and 20 percent of the tributaries. Since 1999, more than $31 million has been spent in Charlotte-Mecklenburg County for land acquisition. Approximately 4,009 acres have been acquired in this county, including donations of floodplains for greenways. Over $9 million has been spent in Gaston and Lincoln Counties. Today more than 6,000 acres of watershed land is protected.

In addition to land conservation strategies, regulatory protections of landuse and point sources of pollution are also needed in a watershed where much of the land is already developed. In 1996, in response to declining water quality conditions and the need for a broader set of watershed protection tools, the Charlotte-Mecklenburg County Board of Commissioners took a stand in support of clean, useable creeks and lakes by directing staff to develop a plan to ensure that all surface waters in the county were fishable and swimmable, a daunting task considering only about 15 percent of the county's creeks then met the criteria. The Surface Water Improvement and Management (S.W.I.M.) Program was created, and it has been instrumental in the adoption of a countywide stream buffer system, implementation of streamside forestry and restoration projects, the 70 percent reduction of fecal coliform through reduction of sewer discharges, and the reduction of sediment through improved inspection and enforcement of erosion control from construction sites.

Since the MIL Initiative and the S.W.I.M. Program were created, water quality has measur-

The South Central Regional Water Authority (SCRWA) in Connecticut closed an aging treatment plant on Lake Whitney because it could no longer effectively treat the raw water, which had degraded significantly due to heavy development in the watershed. Almost a decade after the plant was shut down, the water authority is investing substantial resources in building a facility with more advanced treatment and filtration capacity that will again make Lake Whitney a safe and viable source. Because they understand the challenges and costs associated with treating degraded water, the SCRWA is now one of the most progressive suppliers in the state when it comes to protecting source water, investing in land conservation and watershed management strategies to protect water resources.

ably improved throughout the MIL Watershed and Charlotte-Mecklenburg County as a whole. Current efforts focus on raising additional funds to protect the remaining high-priority streams, through acquisition and easements and by implementing the second and third phases of the S.W.I.M. Program.

CONTACT: Nancy Brunnemer
ADDRESS: Mecklenburg County Real Estate Department, 1435 West Morehead Street, Suite 120, Charlotte, NC 28208
PHONE: 704-336-8828
EMAIL: brunnnm@co.mecklenburg.nc.us
WEB SITE: http://www.charmeck.org/Departments/LUESA/Water+and+Land+Resources/Programs/Water+Quality

Protecting Water Quantity

In the past 100 years the world population tripled, but water use for human purposes multiplied sixfold!

World Water Council, 2000[19]

The loss of source lands impacts not only the quality of our drinking water, but also the quantity. Development increases demand for drinking water while decreasing the ability of land to recharge water supplies.

When water infiltrates soil, the ground itself becomes a temporary storage tank; rather than evaporating into the atmosphere or flowing out to the ocean, water is stored underground for days, weeks, or years, slowly supplying our water sources. Rainfall needs to infiltrate the ground and recharge groundwaters in order to maintain supplies during dry seasons. Where land is developed, water infiltrates less and moves more rapidly and in much greater volume than under natural conditions. The result is a decrease in groundwater flows into streams, less recharge into aquifers, an increase in the magnitude and frequency of severe floods, and high stream velocities that cause severe erosion, damaging water quality, aquatic habitat, and infrastructure.[20] Additionally, removing groundwater at a faster rate than recharge can replace it causes permanent loss of groundwater storage capacity, increased movement of contaminated groundwater into clean groundwater, more saltwater intrusion into coastal basins, and reductions in stream flow.[21]

In addition to decreasing infiltration, sprawling suburban-style development also contributes to water scarcity because it promotes more lawn areas and larger lots planted with turf grass. According to the EPA, an average of 32 percent of residential water use is for outdoor purposes. A study in the Seattle metropolitan area found significant differences in water use among suburban-style housing. Large suburban properties consumed as much as 16 times more water than did homes on a more traditional urban grid with smaller lots. Per capita use of public water is about 50 percent higher in the western United States than in the east, due to the amount of landscape irrigation needed to maintain lawns in more arid regions.[22]

Increased imperviousness, over-appropriated rivers, and excessive groundwater pumping have become serious problems across the United States. Many eastern communities are now facing frequent water shortages similar to those of their western counterparts. For much of the mid-Atlantic region, 2002 was the driest year in over 100 years of record-keeping, as communities up and down the coast declared drought emergencies and implemented water restrictions.

A recent American Rivers report looked at the change in the amount of impervious, or paved, surfaces from 1982 to 1997 in cities around the country. American Rivers sought to estimate the amount of water "lost" to runoff and evaporation as a result of increased development and impervious surfaces. A key finding was that the potential amount of water lost annually ranged from 57 billion to 133 billion gallons in the Atlanta metropolitan area alone. Atlanta's losses in 1997 amounted to enough water to supply the average daily household needs of 1.5 million to 3.6 million people per year.[23]

"In the past, water barely even entered into our calculations," says J.T. Williams, chairman of Killearn, Inc., which has developed thousands of golf courses and clubhouse community homes in the Atlanta metro area in recent years. But now, Mr. Williams admits, "People in the development industry are a little nervous," with water wars brewing in Georgia, Alabama, and Florida.[24]

CASE STUDY

Brick Township, New Jersey

The Brick Municipal Utility Authority (MUA) provides drinking water to more than 100,000 residents in Brick Township and Point Pleasant Beach, drawing 75 percent of its raw water from the Metedeconk River and 25 percent from deep and shallow wells. Throughout the Metedeconk Watershed, seven other communities also draw their drinking water from wells.

The Metedeconk River Watershed, with its headwaters in Turkey Swamp Wildlife Management Area, has benefited from extensive wetlands that cover 30 percent of the watershed, relatively intact riparian forests, gentle topography, and sandy, well-drained soils. As a result,

CHALLENGES FOR SMALL WATER SYSTEMS

The more than 45,000 small community water systems in the country serve fewer than 3,300 people each. Over 30,000 of these systems are very small, serving fewer than 500 people each. Because of less stringent disinfection requirements and the large number of small, rural groundwater supplies, groundwater sources for small communities violate drinking water standards for microbes and chemicals almost twice as often as those serving larger communities—58 percent of outbreaks as opposed to 33 percent[25]—leaving people served by these systems even more vulnerable to outbreaks of waterborne illness.[26]

The vast majority of small water systems use groundwater supplies, which are threatened primarily by bacteria from rural septic effluent. It can be particularly challenging and costly for small water suppliers to upgrade treatment technologies to address contamination threats and to meet increasingly strict drinking water standards.[27] A $100,000 capital investment is considered minor for a system that serves over 300,000 people, yet it may be out of reach for a system serving fewer than 5,000 people. In 2000, almost 40 percent of privately owned community water systems serving fewer than 500 people suffered financial losses, as compared to only 5 percent of those serving over 100,000 people.[28]

According to the Committee on Small Water Supply Systems assembled by the National Research Council, "small water suppliers should seek the cleanest water supply available and protect that resource before investing in new treatment technologies, other than disinfection."[29]

The National Rural Water Association (NRWA) assists small suppliers around the country with planning and implementing source protection strategies in order to protect public health and avoid costly treatment upgrades. According to Jennifer Palmiotto of the Northeast Rural Water Association, a regional office of NRWA,

> small rural water systems are faced with increasingly complex challenges. In order to safeguard public health, water systems must meet the requirements of ever-growing regulations and monitoring demands while struggling to make ends meet. Many of these rural systems are managed by volunteer boards and have one operator, who is also often a volunteer with limited time and limited training. Rates tend to be very low and there is very little will to invest in system upgrades unless there is a crisis, as rural residents assume their raw water is clean. At NeRWA, we try to help small systems address these challenges with on-site technical assistance in operation, maintenance, finance, governance and source protection planning.[30]

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Source water protection is critical for small communities dependent on local groundwater supplies.

CASE STUDY

West Groton Water Supply District, Massachusetts

The West Groton Water Supply District supplies water to approximately 520 households in West Groton, Massachusetts. The sole source of drinking water is a well field located in a shallow, sand-and-gravel-stratified drift aquifer with 47 interconnected wells. The aquifer is only 30 feet deep and is directly under the influence of surface water. It is thus highly susceptible to contamination from inappropriate landuse.

For years the West Groton Water Supply District has been proactive about purchasing and protecting land in its Zone I source protection area (a 250-foot buffer around the well field), and critical parcels in its secondary Zone II source protection area. Because it is a small district with limited resources, it needs to be strategic about when and how to acquire land and finance its long-term protection.

In 1985, the Water Supply District detected trace amounts of Trichloroethylene (TCE) solvents (a petroleum by-product) in its source water. A machine shop in the Zone II protection area was identified as the source. The TCE was no longer detected shortly after the machine shop was closed. Fifteen years later, the landowner decided to sell the 1.5-acre commercially zoned property. In order to avoid potential future contamination from commercial use of the property, the Water Supply District decided to acquire it. The Water Supply District had only $60,000 in reserves to spend, which was not nearly enough to cover the $250,000 asking price and the need for environmental assessments and potential clean-up. In order to protect the property, the Water Supply District needed a creative solution.

Aside from the machine shop, the only other building on the lot was a small house, which was not deemed a source water threat. The Water Supply District wanted to control only the commercial portion of the site but could not buy it separately from the rest of the property. If it bought the entire parcel as a public entity, the Water Supply District would not be able to resell any portion of it to recoup costs.

To solve the dilemma, the Water Supply District created the West Groton Water Supply District Realty Trust to own and manage the land. This allowed it to purchase the property, subdivide it, and resell the house. The house was subsequently placed back on the tax rolls, and most important, the Water Supply District recouped $200,000 of its $260,000 investment. The district continues to control the commercial site, using it for storage, and the creek that runs through the property and is hydrologically linked to their well fields.

During negotiations with the landowner, the Water Supply District completed an environmental assessment of the property and discovered leaking underground oil tanks. The Massachusetts Department of Environmental Protection immediately removed the tanks and began clean-up. By controlling the site, the Water Supply District was able to avoid the future contamination of their well fields and the potentially significant public health threat and clean-up costs.

CONTACT: Gordon Newell
ADDRESS: West Groton Water Supply District, P.O. Box 246, West Groton, MA 01472
PHONE: 978-448-3711
FAX: 978-425-9372

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New Jersey's Turkey Swamp Wildlife Management Area, which expanded in 2001 to include the Metedeconk River and Toms River headwaters, safeguards the Barnegat Bay watershed and the region's water supply.

storm water runoff is slower, infiltrates more easily, and is cleansed naturally by large wetland forests. With urban development now covering 35 percent of the watershed, rainwater flows overland and out to the ocean, instead of infiltrating into the ground and recharging the shallow aquifer. In this way it is lost as a potential freshwater source. Although Brick MUA draws most of its water from the Metedeconk River, it is almost completely dependent on the shallow aquifer for its supply, as 60 to 80 percent of the Metedeconk's baseflow comes from groundwater.

After almost four years of drought conditions, water quantity has become a critical issue for local water suppliers and residents alike. In 2002, severe restrictions had to be placed on water use to ensure that water supplies would last into the fall, when authorities could only hope for rain. The restrictions included a mandatory ban on all nonessential outdoor water use, including no watering of lawns and gardens; no washing of cars, buildings, sidewalks, and driveways; and no outdoor use of water for ornamental or aesthetic purposes, including fountains. It also banned serving water in restaurants, unless specifically requested by the patron. Eventually, low rainfall caused salt water intrusion into the Metedeconk River, forcing Brick MUA to shut down its surface water intake and rely solely on groundwater wells, which were also low.

Although the drought led to severe restrictions on water use, it brought a beneficial awareness to watershed residents of the threats to their water supply, creating greater support for watershed protection. The Brick MUA is taking advantage of this increased interest and of the incentives provided by new storm water management regulations, and is expanding its source protection activities. In 2002, Brick MUA hired a Watershed Coordinator to facilitate activities with the seven townships and two counties in the watershed and is looking at ways to build partnerships and provide incentives for watershed protection and growth management. Brick MUA plans to work with other jurisdictions to develop storm water management plans, educate the public, and implement protection and restoration activities. Additionally, in order to better understand their watershed and to guide and support protection strategies, Brick MUA has implemented a Watershed Management Model to estimate runoff and pollutant loads.

Building on Brick MUA's monitoring and modeling program, priority areas for protection and restoration have been mapped throughout the watershed. In 2001, the Trust for Public Land, working in partnership with Freehold Township in Monmouth County and Jackson Township in Ocean County, purchased over 1,794 acres adjacent to Turkey Swamp Wildlife Refuge, expanding the refuge's boundaries and protecting critical wetlands and forests in the headwaters. Brick MUA will continue to work with TPL and others to protect land critical to groundwater recharge, ensuring the quality and quantity of future supplies.

CONTACT: Rob Karl, Source Water Administrator
ADDRESS: Brick Municipal Utility Authority, 1551 Highway 88 West, Brick, NJ 08724
PHONE: 732-458-7000, ext. 271
EMAIL: LGialanella@brickmua.com
WEB SITE: http://www.brickmua.com

Drinking Water and Public Health

Throughout history, the contaminants in source waters have changed, as has our understanding of what is safe and what is not. The introduction of chlorine in the early 20th century, combined with filtration, dramatically reduced waterborne disease in the United States and has made the American water supply one of the safest in the world. But these technological advances have caused people to question the importance of protecting source lands. "The bargain made by some communities of a century ago was to trade source water protection for a future reliance on water treatment. The wisest choice is to marry the two together whenever possible,"[31] according to Dr. Jeffrey Griffiths, Director, Graduate Programs in Public Health, Tufts University School of Medicine.

Some of the treatment challenges faced by suppliers drawing from intensively used source lands include:

1. The emergence of new contaminants that suppliers may not be prepared to test for or treat
2. Spikes in contaminant loads due to storms and flooding that make treatment more challenging
3. Constantly changing standards and regulations regarding new contaminants, which are present in the water long before they are identified as threats to public health

This section takes a close look at these public health challenges. With an understanding of the threats comes an ability to provide clean and plentiful drinking water supplies into the future. Keep in mind that local governments and water suppliers have the most critical responsibility where source protection is concerned. Public and private water suppliers are responsible for providing drinking water that meets Safe Drinking Water Act standards; both can and should take action to ensure the ongoing safety and availability of their source water.

Emerging Contaminants

The threat to public health from emerging contaminants presents the most compelling reason to protect drinking water sources. Emerging contaminants are contaminants that either are new to the environment (new diseases or chemicals) or have only recently been identified as potential health threats.

In the 1980s, Cryptosporidium, a waterborne pathogen, was first identified as a potential threat to human health. By the early 1990s multiple large outbreaks of cryptosporidiosis were traced to infected drinking water sources. Although some suppliers had been required by the EPA to test for Cryptosporidium and some were testing voluntarily, it was not until 2002 that rules were passed requiring all suppliers to test for and treat Cryptosporidium.

Emerging pathogens pose one of the greatest waterborne threats to public health. According to epidemiologists, recently emerging pathogens, such as Cryptosporidium, Giardia, and Hepatitis E,[32] share similar characteristics. They tend to be:[33]

- Resistant to chlorination or disinfection
- Resistant to antibiotics or have no medical treatment
- Spread by animals as well as humans
- Highly infectious—small numbers of microbes can cause illness

That last characteristic means that isolated and chronic waterborne diseases can go undetected or unrecognized, because current methods of detection may not be suitable to detect low levels of microbe infiltration.[34] A nationwide study of waterborne disease outbreaks found that epidemic outbreaks of waterborne disease have been recognized only after thousands of acute cases were reported.[35]

In addition to pathogens, emerging contaminants include chemicals, metals, and pharmaceuticals. According to Daniel Okun, a leading environmental engineer at the University of North Carolina, new knowledge about the health impacts of chemicals has made them a primary concern among epidemiologists studying emerging threats in drinking water.[36]

Industries invent and put on the market new chemical compounds daily, such as pesticides for agriculture, pharmaceuticals, and chemicals for plastics. Because we increasingly live and work in our drinking water watersheds, these manmade chemicals eventually reach our water sources via septic systems, storm sewer overflows, and runoff from lawns and farms.

With the increasing diversity of manmade chemicals reaching our waterways, and with the need for special testing methods to identify and measure them, these emerging contaminants can go undetected.[37] A recent study by the U.S. Geological Survey included a list of potential emerging contaminants that have largely been ignored

Clean water, clean food, and sewerage have led to two-thirds of the increase in life span from 1900 to today. Drinking water degradation is a critical threat to the foundation of our societies.[38]

Dr. Jeffrey Griffiths, MD MPH & TM, Tufts University School of Medicine

"It is difficult to know what new contaminants might be in the watershed that could make it to the treatment facility, and therefore what treatment process will be most effective at safely removing them," explains Chris Crockett, Manager of Philadelphia Water Department's Source Water Protection Program. "From a public health perspective, it is prudent to manage and protect the source area to the degree possible to prevent contaminants from reaching the raw water source in the first place."[39]

by researchers to date, such as nonprescription drugs and plasticizers, and it developed new monitoring techniques to measure these contaminants' prevalence in our waterways. Through nationwide monitoring, researchers found steroids and nonprescription drugs in over 80 percent of the 139 streams tested. The highest concentrations were of detergents, steroids, and plasticizers. This monitoring effort represents significant progress in identifying and measuring emerging contaminants in our waterways, but it points to the fact that our ability to identify and measure contaminants will always be behind their emergence as a threat.[40]

Conventional treatment processes, such as clarification and filtration, remove many known and as yet unknown contaminants, yet they typically do little to remove most pesticides or pharmaceuticals. Not much is known about the toxicity of these substances at low levels and in complex mixtures, making it difficult to predict even potential health effects on humans. Also, we don't know much about how common processes, such as disinfection, alter the structure of many of these chemicals and the types and toxicity of the by-products that may be produced.[41]

CASE STUDY

Carroll County, Georgia

The Upper Little Tallapoosa River Watershed is located in Carroll County, about 50 miles west of Atlanta, Georgia. A series of small reservoirs on the Little Tallapoosa River provide drinking water for 30,000 people. The fertile lands of the Little Tallapoosa River Watershed have enabled Carroll County to become the second leading producer of beef cattle in Georgia, but development, moving west from Atlanta, is quickly encroaching on agricultural lands. No public sewer exists in much of the county, and individual on-site septic systems are proliferating.

The first known major outbreak of Cryptosporidium in the world occurred in the Upper Little Tallapoosa Watershed in the city of Carrollton and Carroll County in January 1987. Immediately following the outbreak, water trucks had to be brought in to serve the residents, and restaurants imported ice and water from Alabama. "There was a period of time when you couldn't get a drink of water from a restaurant in Carrollton," says Curtis Hollabaugh, a longtime resident and university professor at West Georgia College, where the outbreak was first discovered.

In response to the outbreak, U.S. EPA and Georgia EPA inspectors worked with City of Carrollton engineers to evaluate the cause of the outbreak and to upgrade the filtration system to address the problem. The costs to upgrade the system came to almost $280,000—a significant cost for a relatively small supplier. Though many in the city and county were left sickened by water, in the years that followed the outbreak the public maintained a heightened awareness and understanding of watershed activities and water quality.

Although the new treatment processes initiated after the outbreak successfully controlled the threat from Cryptosporidium and other pathogens, in the seventeen years since the outbreak, increasing sediment and organic loads, most likely from cattle in the streams and new development, have made treatment more difficult and expensive. The increased treatment needed to address high organic loads has contributed to an increase in unwanted disinfection by-products (DBPs). In recent years, DBPs have on occasion exceeded water quality standards. Because DBPs are a by-product of the disinfection process, one of the best ways to reduce them is to reduce organic pollutant loads in the raw water, thereby decreasing the degree of disinfection required. Basically, cleaner water requires less treatment and results in fewer treatment by-products.

In 2002, Carroll County applied for and became a demonstration site for the Trust for Public Land and U.S. EPA to study source water protection activities that could result in cleaner water. Led by County Chairman Robert Barr, the Upper Little Tallapoosa Steering Committee has embraced a series of recommendations from the study that focus on better watershed management for safe drinking water. Some of the source protection efforts under way as a result of this study include the development of watershed protection ordinances, a plan for managing wastewater and on-site septic systems, outreach to farmers on best management practices, the acquisition of lands critical to protecting source water, and the establishment of a dedicated local funding source for land protection. In November 2003, voters approved new funding via a local sales tax that will direct about $20 million toward land acquisition for source water protection and public recreation.

CONTACT: Amy Goolsby
ADDRESS: Carroll County Department of Community Development, Carroll County Administration Building, P.O. Box 338, Carrollton, GA 30117
PHONE: 770-830-5800
FAX: 770-830-5992
EMAIL: agoolsby@carrollcountyga.com
WEB SITE: http://www.carrollcountyga.com

Spikes in Pollutant Loads

Spikes in pollutant loads are caused by the accumulation of pollutants in the watershed over time and the transport of those pollutants to waterways during rainfall or snowmelt. These pollutants are eventually flushed into a receiving body of water, such as a lake, reservoir, or large river, via storm water runoff or storm sewer overflows. Because spikes usually occur during heavy rains, and because the pollutants accumulate throughout the watershed and over a period of time, it is very difficult to accurately target sources and to measure the impact of pollution on water quality and public health.

As forests in our watersheds and aquifer recharge areas are replaced by development, more water runs over the surface of the land at greater speeds, quickly carrying heavy loads of pollutants to our water treatment plants. Even though the series of barriers in a modern water supplier's infrastructure should effectively prevent these pollutants from reaching consumers, the failure of even a single stage threatens the entire system. Consequently, spikes in pollutant loads can have serious public health consequences. Various estimates suggest that between 900,000 and two million people become ill each year in the United States by ingesting protozoan, bacterial, and viral pathogens in incompletely treated and untreated drinking water from community water supplies.[42]

In Milwaukee, Wisconsin, in 1993, more than 403,000 people became ill and an estimated 54 people died as a result of an outbreak caused by Cryptosporidium that contaminated the water during a rainstorm, which carried heavy pollutant loads to the treatment plant.[43] In 1990 in Cabool, Missouri, four people died and 243 were stricken ill from drinking water contaminated with hemolytic E. coli from pasturelands. In Walkerton, Ontario, in 2000, seven people died and more than 2,300 became ill when the drinking water system became contaminated during a rainstorm with E. coli and Campylobacter jejuni, which reached the intake from a nearby field recently fertilized with animal waste.[44] In each of these cases, spikes in pollutant loads from heavy surface runoff during rainstorms, combined with improper or insufficient drinking water treatment, were the likely causes of contamination. In some cases, the failure of monitoring systems, both at the treatment plant and by the regulatory agencies, meant the outbreaks were not recognized or addressed quickly enough to protect public health.

Occasional spikes in pollutant loads can be very expensive for water suppliers, who must upgrade their treatment facilities to deal with maximum loads. The city of Decatur, Illinois, for instance, spent $8.5 million on a nitrate removal facility in 2001, which is only used to address spikes in pollutant loads during heavy rainfall or storm events. During years with low rainfall, the facility is scarcely used.

CASE STUDY

City of Lenexa, Kansas

Lenexa is a community of over 40,000 residents located in Johnson County, Kansas, in the southwestern Kansas City metropolitan area. The city's location and accessibility have fueled its growth as a business center and resulted in a significant retail base. Three of the city's five main watersheds drain to tributaries of the Kansas River, less than one mile upstream from the county's main water supply intake. Because 50 percent of Lenexa's storm water runoff drains to the county's water supply intake, there is a need for a progressive approach to storm water management and the protection of natural resources.

Because storm water runoff from the city directly impacts the quality of source water for the entire county, local communities are very interested in managing storm water runoff, flooding, and resulting spikes in pollutant loads. Working with consultants from the Black and Veatch Corporation, the city undertook an extensive community planning process to develop a storm water management plan that reduces the risk of flooding and of spikes in pollutant loads to the water supply intake, while providing ancillary community amenities, such as parks and greenways. The watershed-based approach to storm water management that was developed through this planning process incorporated strategies to minimize flooding and deal with storm water runoff by creating a system of in-stream wetland treatments and a chain of lakes and wetlands to provide flood retention and improved water quality. The system of lakes and wetlands includes wetland and riparian filters as well as the implementation of upstream best management practices, such as infiltration basins, aggressive erosion and sediment control practices, stream restoration and conservation, and regional storm water detention. This project has been part of a larger effort to inventory and protect stream corridors with high habitat quality in the developing western portion of the city of Lenexa.

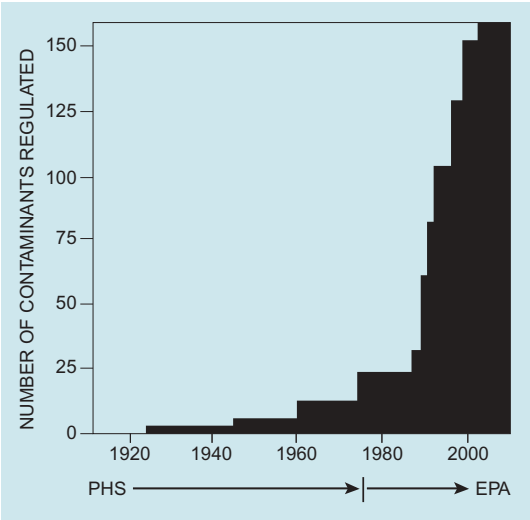
Lenexa is leveraging opportunities created

"There are a large number of chemical compounds that are used extensively in our day-to-day lives and our use of the land and, therefore, occur frequently in the aquatic environment. Because many of them are unregulated in drinking water, their occurrence and concentration in the environment raises water-quality and human-health concerns," explains Carol Storms, Manager of Water Quality, with American Water. "At American Water we understand that regulation of a contaminant is always somewhat behind its occurrence in the raw water, so we monitor extensively to identify potential contaminants of concern and to ensure that our treatment process is adequately removing them."[45]

by the storm water management plan to provide recreational amenities for residents. With the motto "Rain to Recreation," dry-bottom detention basins will be constructed to double as sports fields, and new lakes and protected riparian corridors will be connected to residential and commercial areas via a new greenway trail system.

Implementation of conservation and restoration activities began in the fall of 2000. The city is combining these activities with a mix of incentives and regulations to encourage a more conservation-oriented approach to development. With the U.S. EPA's storm water management rules in effect since the fall of 2003, the city of Lenexa has already met many of the requirements and serves as a model for other communities looking for innovative ways to meet federal storm water management requirements.

CONTACT: Jim Finlen, Lenexa, Kansas
ADDRESS: Parks and Recreation Department, 134 20 Oak Street, Lenexa, KS 66215
PHONE: 913-541-8592
FAX: 913-492-8118
EMAIL: jfinlen@ci.lenexa.ks.us
WEB SITE: http://www.ci.lenexa.ks.us



Number of drinking water contaminants regulated by the U.S. government. The large increase in regulated contaminants that begins after 1976 is due to regulations issued under the Safe Drinking Water Act and its subsequent amendments. Adapted, with permission, from Okun (1996). © 1996, the American Society of Civil Engineers.

Changing Standards

Since the passage of the Safe Drinking Water Act, the EPA has continued to identify compounds that hold the potential to cause cancer and other adverse health effects, and it has set maximum contaminant levels in drinking water for each substance. The establishment of such standards has had a dramatic impact on the quality of drinking water in this country. However, "as any analytical chemist knows, what you see depends on what you look for," says Lynn Roberts, a professor of environmental chemistry at Johns Hopkins University.[46] What you see also depends on the resources and time available to researchers. The inherent challenges of establishing and adapting contaminant standards are as follows:

- The seemingly endless number of known, and as yet unknown, contaminants that need to be identified and studied
- Limited resources available for such research
- The difficulty of drawing clear conclusions about cancer-causing agents, as the onset of cancer may require decades-long exposure and extensive and complex epidemiological research
- The difficulty of assessing health effects from simultaneous exposure to multiple contaminants

It is particularly challenging to set containment standards, as new chemical compounds are constantly reaching our water sources, and their public health risks may not be understood. Until recently, long-term exposure has been the primary concern with chemical compounds and disinfection by-products (DBPs); measuring the impact of average doses over many years has been considered adequate. Current research, however, is showing potential impacts on reproductive systems (endocrine disruptors) that can result from

exposure to chemical compounds and DBPs over periods as short as three months.[47]

Drinking water standards and treatment guidelines have been established for numerous chemicals. However, many chemical compounds do not have standards, and current standards do not yet account for exposure to complex mixtures for long periods at low concentrations, or for seasonal spikes in concentrations.[48]

The Costs of Not Protecting Source Waters

Treatment and filtration, land conservation, new development, and infrastructure—each has a price tag that impacts decisions about drinking water protection. For municipalities and water suppliers, budget constraints and the bottom line factor in throughout the process. What's important is making informed assessments about the costs, both long- and short-term, of source protection in relation to other approaches.

Landuse and protection decisions are often based on short-term (one to five years) revenue and expense projections for local governments, as elected officials decide how to balance land protection policies based on current budgets. However, the impacts of development on water quality and treatment costs are realized over the long term—five to ten years and longer—and are often ignored in landuse planning processes. The short-term costs for protection of source lands can be high, and water suppliers, who understand the long-term cost and public health impacts of watershed development, are not usually involved in landuse or land protection decisions.

It is difficult to establish the impact of landuse alone on water quality. By the time water quality degradation has become apparent and treatment methods need to be upgraded, it is often too late for municipalities and suppliers to choose source water protection as a means for addressing the problem. "For many cities, time is running out," said David Cassells, a World Bank forest specialist. "Protecting forests around water catchment areas is no longer a luxury but a necessity. When they are gone, the costs of providing clean and safe drinking water to urban areas will increase dramatically."[49]

Many communities that have experienced the increased treatment and capital costs of degraded water and the quality-of-life impacts of fast growth are now implementing regulatory and nonregulatory strategies to protect land and encourage more sustainable development patterns. These communities are learning that while land conservation is a big investment, it may also be a bargain compared to the long-term costs of treatment and contamination. This section summarizes the potential costs of not protecting a community's source lands.

Increased Treatment Costs

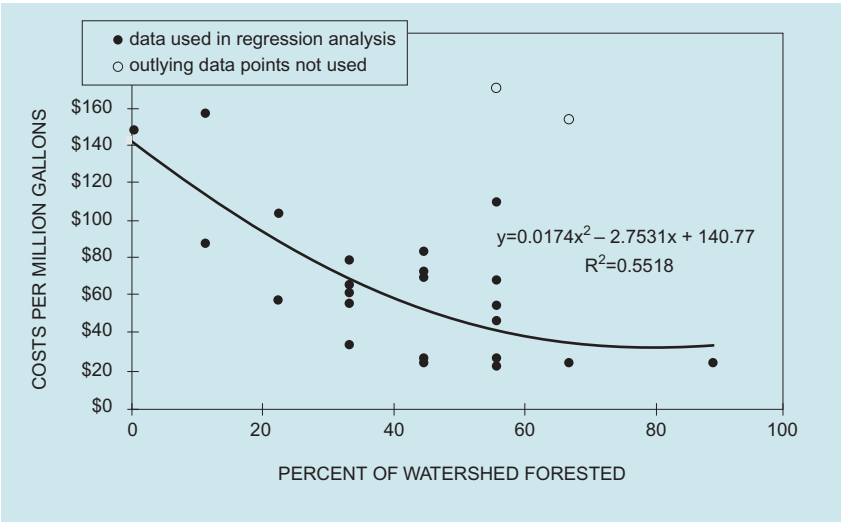
The development of watershed and aquifer recharge lands results in increased contamination of drinking water. With increased contamination come increased treatment costs. The costs can be prevented with a greater emphasis on source protection.

A study of 27 water suppliers conducted by the Trust for Public Land and the American Water Works Association in 2002 found that the more forest cover in a watershed, the lower the treatment costs. According to the study:

- Approximately 50 to 55 percent of the variation in treatment costs can be explained by the percent of forest cover in the source area.[50]
- For every 10 percent increase in forest cover in the source area, treatment and chemical costs *decreased* approximately 20 percent, up to about 60 percent forest cover.

The study did not gather enough data on suppliers with over 65 percent forest cover to draw conclusions; however, it is suspected that treatment costs level off when forest cover is between 70 and 100 percent. The 50 percent variation in

"When rapid development in Mecklenburg County began to impact the Mountain Island Lake Watershed, which provides drinking water to 600,000 county residents, it was a wake-up call to the community that we needed to act now to protect our drinking water," says Ruth Samuelson, Mecklenburg County Commissioner. "In addition to the cost of treatment for a degraded water supply, the loss of our forests and natural landscapes threatened the quality of life in our community. Today, Mecklenburg County owns over 4,000 acres, an eighth of the total of Mountain Island Lake Watershed."[51]



WATERSHED FORESTED	TREATMENT AND CHEMICAL COSTS PER MG	CHANGE IN COSTS	AVERAGE TREATMENT COSTS PER DAY	PER YEAR
10%	$115	19%	$2,530	$923,450
20%	$93	20%	$2,046	$746,790
30%	$73	21%	$1,606	$586,190
40%	$58	21%	$1,276	$465,740
50%	$46	21%	$1,012	$369,380
60%	$37	19%	$814	$297,110

treatment costs that cannot be explained by the percent forest cover in the watershed is likely explained by varying treatment practices, the size of the facility (larger facilities realize economies of scale), the location and intensity of development and row crops in the watershed, and agricultural, urban, and forestry management practices.[52]

The table above shows the change in treatment costs predicted by this analysis, and the average daily and yearly cost of treatment if a supplier treats 22 million gallons per day—the average production of the surveyed suppliers.[53] (The percentage change in costs starts at zero percent forest cover: from zero percent forest cover to 10 percent forest cover, treatment costs decrease 19 percent.)

A similar study was conducted in 1997 by the Department of Agricultural Economics at Texas A&M University.[55] From a sample of 12 geographically representative suppliers with three years of data, researchers found that:

- Suppliers in source areas with chemical contaminants paid $25 more per million gallons to treat their water than suppliers in source areas where no chemical contaminants were detected.
- For every 4 percent increase in raw water turbidity, treatment costs increase 1 percent. Increased turbidity, which indicates the presence of sediment, algae, and other microorganisms in the water, is a direct result of increased development, poor forestry practices, mining, or intensive farming in the watershed.

Some utilities understand that protected lands mean protected water quality and are working to prevent future increases in treatment costs through targeted land conservation. Kirk Nixon at San Antonio Water System is developing ways to measure the water quality, quantity, and financial benefits of their successful effort to protect approximately 15,888 acres of aquifer recharge land over the past five years, the total acreage from both the San Antonio Water System Sensitive Land Acquisition Program and the City of San Antonio Proposition 3 Initiative.

According to Nixon, "The benefits of these types of programs are quite difficult to quantify. It is a difficult task to compare actual land development and the associated storm water treatment required versus conserving land in a natural, undeveloped state. These are the very issues that we at the San Antonio Water System, in cooperation with other entities, are striving to resolve. Through a cooperative agreement with USGS, we are conducting pollutant loading studies, recharge and runoff estimation models, and hydrogeologic and vulnerability mapping projects. In the first phase of our study, we're establishing gauging and sampling stations on small, specific landuse watersheds, collecting the data, and characterizing the impacts from various landuses on the Edward's Aquifer Recharge Zone. In the second phase, we will calibrate a watershed model to predict runoff, constituent loads, and recharge on the Bexar County portion of the recharge zone."[54]

Increased Capital Investment in New Treatment Technologies

The impact of development and loss of forestland on water quality happens over time and is usually greatest during periods of heavy rainfall. At first, heavy pollutant loads are isolated events during storms. Gradually, larger and more complex pollutant loads appear with greater frequency and severity until an acute event or revised water quality regulations cause suppliers to alter treatment strategies or upgrade facilities.

Upgrading treatment systems can be extremely expensive. Between 1996 and 1998 the City of Wilmington, North Carolina, spent $36 million to add ozonation and to expand its treatment facility, in part as a result of an increase in industrial and agricultural runoff in their watershed. In 2000, Danville, Illinois, invested $5 million in a nitrate removal facility to deal with spikes in nitrogen resulting from agricultural runoff. In 2001, Decatur, Illinois, invested $8.5 million in a nitrate removal facility, also to deal with agricultural runoff.

New water quality regulations are often the final impetus for treatment upgrades. However, suppliers with protected source waters are less likely to be forced to invest in major upgrades because their pollution concentrations are more likely to remain below maximum allowed levels. In fact, EPA's proposed Long Term 2 Enhanced Surface Water Treatment Rule embodies the principle that higher quality waters require less treatment. This rule establishes additional treatment requirements for water treatment plants that draw from sources with elevated levels of Cryptosporidium.[56]

Loss of Consumer Confidence—A High Price to Pay

When water quality causes illness or even just an unusual taste, odor, or color, the public quickly loses confidence in the safety of its supply. An erosion of public trust costs both the supplier and the community, often leading to broader economic impacts in addition to treatment and capital costs. Residents begin buying bottled water and household filtration systems, and local businesses that rely on clean water install their own filtration systems. In some cases, businesses and individuals may choose not to live or work in a community because they perceive it has poor water quality.

The impacts of contamination and waterborne disease outbreaks should not just be measured economically. They should also be measured in human terms. In an inquiry into an E. coli outbreak in Walkerton, Ontario, in 2000, the investigator wrote that the most important consequences of the outbreak were in the "suffering endured by those who were infected; the anxiety of their families, friends, and neighbors; the losses experienced by those whose loved ones died; and the uncertainty and worry about why this happened and what the future would bring."[57]

CASE STUDY

New York, New York

New York City supplies the nation's largest metropolitan area with surface water from 19 reservoirs and three controlled lakes. It serves nine million users and delivers approximately 1.3 billion gallons per day from a 2,000-square-mile watershed in parts of eight upstate counties. Protecting the purity of this source water became an even higher priority for the city with the Safe Drinking Water Act (SDWA) amendments in the late 1980s that directed the EPA to develop criteria for filtration. The vast bulk of the city's drinking water (approximately 90 percent) comes from two systems known as the Catskill and Delaware water supplies. After allowing the city to operate supplies for a brief period of time without filtration, the EPA put the city on notice: develop and implement a comprehensive program to protect the Catskill and Delaware Watersheds, or filter the water. At the time, the city owned less than 8 percent of its watersheds. Faced with the prospect of spending $6 to 8 billion on a new Catskill/Delaware filtration plant and $300 million in annual operating expenses, the city chose to take on an aggressive watershed management plan with land acquisition as its centerpiece. A new filtration plant would have resulted in the likely doubling of water rates.

In January 1997, the City of New York, through its Department of Environmental Protection (NYC-DEP), entered into a groundbreaking Watershed Memorandum of Agreement with some 76 signatories, including the EPA, the State of New York, virtually all of the counties, towns, and villages in its watersheds, and a number of environmental and public interest organizations, including TPL. This agreement established a far-reaching program to protect all three of the city's watersheds—Catskill, Delaware, and Croton—including adoption of new watershed regulations, environmental and economic partnerships with watershed communities, and a watershed land acquisition program. All together, the city projects spending approximately $1.2 billion over the first 10 years on a variety of watershed improvements. The agreement, which by protecting the watershed allows New York to avoid filtration for its Catskill and Delaware plants, includes direct city investment in upstate water pollution controls. Acknowledging that upstate users are the stewards of city water, the city realized that providing financial and technical resources to enable that stewardship was in the city's best interest. For example, the city is spending approximately $270 million to bring all 114 existing wastewater treatment plants in the watershed up to tertiary treatment standards.

The city expects to purchase land in fee or to purchase conservation easements on land for watershed protection. With 355,000 acres under consideration, NYC-DEP had to establish prioritization criteria to determine which tracts are most essential for maintaining pollution-free source water. Through GIS modeling, planners identified the land with the most potential impact on water quality as acquisition priorities. Five priority areas were established for the Catskill and Delaware Watersheds and three for the Croton Watershed. In the Catskill and Delaware Watersheds, each priority area has certain natural features criteria, including minimum parcel size, that define land that is eligible for purchase. The city agreed to solicit percentages of eligible land in each Catskill/Delaware priority area, ranging from 95 percent in the highest priority to 50 percent in the lowest.

Funding for these programs is expected to come from utility user fees, bonding, and state and federal funding sources, including SDWA funding, U.S. Army Corps funding, and USDA

Auburn, Maine, saved $30 million in capital costs, and an additional $750,000 in annual operating costs, by spending $570,000 to acquire land in their watershed. By protecting 434 acres of land around Lake Auburn, the water systems are able to maintain water quality standards and avoid building a new filtration plant. Funding for the land acquisition came from a Drinking Water State Revolving Fund Loan to the Auburn Water Department.

The town of Maynard, Massachusetts, a rapidly developing community in the Boston metropolitan area, experienced a dramatic increase in the levels of iron and manganese in their groundwater as a result of increased urban runoff. The water had become discolored, leading to a surge in complaints from customers concerned about the safety of the water. Although discoloration from iron and manganese is not a threat to public health, expensive treatment is required to remove it. As a result of public concern, the town voted to approve a new $4.6 million treatment facility.[58]

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By protecting the watersheds supplying its nine million residents with drinking water, New York City expects to both improve water quality and save money that would have gone toward construction and operation of a new filtration plant.

funding—and is expected to be far less than the cost of construction and operation for a filtration plant. More importantly, the watershed protection activities are beginning to show success in addressing water quality challenges. The phosphorus loads from wastewater treatment plants in the watershed between 1994 and 1999 dropped by 65.7 percent. Of this reduction, about 77 percent appears to be due to treatment performance that has been aggressively addressed by Department of Environmental Protection staff. Treatment plant upgrades and storm water management plans, including watershed buffers and wetlands protection, are expected to lead to even better results in the future. As a result of these improvements, EPA agreed in November 2002 to extend filtration avoidance for another five years.

CONTACT: Mark Hoffer, General Counsel
ADDRESS: New York City Department of Environmental Protection, Bureau of Legal Affairs, 59-17 Junction Boulevard, 19th Floor, Corona, NY 11368
PHONE: 718-595-6528
FAX: 718-595-6543
EMAIL: mhoffer@dep.nyc.gov

CASE STUDY

Salem, Oregon

The City of Salem's water system currently supplies drinking water to approximately 170,000 people. The city relies almost entirely on the North Santiam River for its water supply source. Salem's watershed covers more than 490,000 acres of land stretching from the Cascade Mountain peaks of Mount Jefferson and Three-Fingered Jack to the city's water intake above Stayton. Approximately 80 percent of the land in the watershed is owned and managed by the United States Forest Service, the Bureau of Land Management, and the Oregon Department of Forestry, which harvest timber on much of the land. A few small but growing communities with a combined population of about 2,700 are located along the river.

After unusual flooding on the North Santiam River in Oregon in February 1996, the City of Salem was forced to take drastic steps to provide potable water to its customers. Salem's water treatment system relies on slow sand filtration, which is a very efficient and effective way to treat the normally clear waters of the North Santiam River. However, high turbidity causes the filter system to plug quickly. The water intake from the river is normally shut down when turbidity exceeds 8 nephelometric turbidity units (ntu). During and after the February flood, the river reached 140 ntu twice and did not fall below 8 ntu until two months after the flood. Due to the severe limitations on providing adequate water supplies in the aftermath of the flood, the city was forced to declare a water emergency. The resulting cost for the city to keep water supplied to customers was more than $200,000. Due to the impacts from the 1996 flood, the city built a permanent Chemical Pretreatment System that cost approximately $1 million. For a city that spends less than $27 per million gallons for treatment, an unexpected $1 million investment is significant.

The U.S. General Accounting Office (GAO) report *Oregon Watersheds: Many Activities Contribute to Increased Turbidity During Large Storms* (July 1998, GAO/RCED-98-220) found that, although the watershed seems well protected, timber harvesting and related road construction practices contributed to heavy soil erosion during the 1996 storm. Also contributing to flooding and significant erosion on the 20 percent of land not in public ownership were agricultural, urban, and residential development, including a highway that parallels the city's sole source of drinking water.

Since the 1996 flood, the city has worked

closely with local, state, and federal agencies to implement better watershed management practices to protect its drinking water and avoid future episodes of contamination. The city signed a Memorandum of Understanding with all federal agencies in the watershed that outlines watershed protection goals and created an online water quality monitoring program that is cost-shared with the U.S. Geological Survey (http://oregon.usgs.gov/santiam/). The city also participates in initial site assessments for all timber sales with the Bureau of Land Management (BLM), the U.S. Forest Service (USFS), and the Oregon Department of Forestry (ODF). The results of water quality monitoring to measure the impact of watershed protection efforts can be viewed in the first report by the U.S. Geological Survey on this effort at http://oregon.usgs.gov/pubs_dir/WRIR03-4098/. Although improving water quality and maintaining treatment costs are the city's long-term goals, the city considers its positive relationships with the USFS, BLM, and ODF to be an immediate benefit of cooperative actions.

CONTACT: Libby Barg, Water Quality and Treatment Supervisor, City of Salem Public Works
ADDRESS: 1410 20th Street SE, Salem, OR 97302
PHONE: 503-361-2224
FAX: 503-588-6480
EMAIL: lbarg@open.org
WEB SITE: http://cityofsalem.net/~swater

Watershed Management: The First Barrier in a Multiple-Barrier Approach

Watershed management is the first and most fundamental step in a multiple-barrier approach to protecting drinking water. Healthy, functioning watersheds naturally filter pollutants and moderate water quantity by slowing surface runoff and increasing the infiltration of water into the soil. The result is less flooding and soil erosion, cleaner water downstream, and greater groundwater reserves.

Watershed management is a multifaceted discipline that involves conservation and restoration, landuse monitoring, proactive landuse regulations, on-site field inspections, education, planning, emergency spill response, and incentives. Although all of these components are essential to improving water resources, only the protection of land prevents contamination by nonpoint source pollutants and costly clean-up of drinking water.

Land can and should be protected with both regulatory and voluntary tools. Yet in the past, many communities have relied too heavily on regulatory landuse strategies; although these are critical to any land management plan, as a singular approach they can place excessive burdens on landowners in the source area. In addition, they may be difficult or even impossible to implement for communities that do not have the authority to regulate landuses within the source area they need to protect.

Voluntary tools include land conservation, best management practices (BMPs), and public education. BMPs can be effective over time by changing the behaviors and practices of those in the watershed, but they may be insufficient on their own to protect water resources. Such voluntary compliance strategies are usually most effective when combined with other approaches, such as landuse regulation or land conservation. Voluntary land protection strategies provide permanent protection for critical natural resources. Land and development rights are acquired from willing sellers in a process that is fair to both sellers and buyers. Specific tools include the acquisition of land or conservation easements and several leasing arrangements.

The American Academy of Microbiology, in their 1996 study on water safety, argued that one of the best tools for reducing the transmission of waterborne diseases is the establishment of watershed protection programs.[60]

Given the array of protection tools, where does land conservation work best? Protection of natural lands will benefit any ground and surface water sources, but conservation is particularly effective in defined circumstances.

- *Size.* The smaller the drainage area, the easier it is to accomplish measurable water quality objectives. Water suppliers who choose land conservation as a primary strategy usually have drainage basins or aquifer recharge areas of 300,000 acres or less.[59]
- *Existing or potential landuses.* Land conservation strategies are more politically salient in communities where tracts of unprotected forest or grasslands are still privately owned, or where water quality has declined measurably as a result of landuse, such as new development.
- *Overlapping benefits.* Communities that have other land protection goals, such as growth management or flood control, in addition to water quality, are more likely to support funding for land conservation.

New knowledge about watershed hydrology and the flow of pollutants through the watershed is allowing communities to make smarter invest-

Serving Chapel Hill and Carrboro, North Carolina, Orange Water and Sewer Authority (OWASA) uses their land acquisition program to purchase the most sensitive land in their watershed to protect their drinking water source through negotiations with interested landowners. By paying landowners for the value of their property, OWASA "actually puts money back into the pockets of watershed landowners who more typically perceive themselves as 'victims' of source water zoning and development restrictions. This has been a successful response to the challenging issue of equity," notes Ed Holland, planning director. "Source water protection has traditionally enjoyed a high level of support by the environmentally conscious community we serve. Our Five-Year Capital Improvements Budget typically includes over $2 million for watershed land and easement acquisition."[61]

ments in land conservation that have the greatest benefit for drinking water resources. Land conservation can be used to protect both surface water and groundwater resources.

Surface Water Protection

Traditional land protection strategies have focused on protecting riparian areas along large rivers or reservoir shorelines, often ignoring the smaller feeder streams. We now understand that the greatest volume of runoff water, and therefore the greatest volume of pollutants, enters most watersheds from small streams.

Within any particular watershed, small streams constitute up to 85 percent of the total stream length and collect most of the surface runoff and pollutants from the land.[62] Because small headwater and tributary streams comprise most of the drainage network in watersheds, they strongly influence the quantity, timing, and quality of streamflow. However, due to their size, small streams are rarely mapped by many local governments and are often ignored during planning processes.

Recent scientific studies show that protecting small streams and their riparian zones can have a greater impact on maintaining water quality and quantity than protection of larger tributaries.[63] Watershed managers are beginning to target the protection of small streams and their riparian zones.

Groundwater Protection

In the past, most groundwater protection efforts have focused on wellhead protection—protecting the area immediately surrounding the wellhead, where contaminants can reach the treatment plant quickly and with little time for detection. Although wellhead protection is important, pathogens and soluble pollutants, such as nitrate, can travel long distances in groundwater (in some cases very rapidly) and may even reach deep aquifers.[64] Once water flows underground and settles in an aquifer, it may remain there for hundreds to thousands of years. If pollutants reach an aquifer, particularly a deep aquifer, contamination may be essentially permanent.[65] Protecting deep or confined aquifers from contamination requires protecting land in the aquifer recharge zone. Protecting the wellhead may not be sufficient to protect the aquifer from contamination.

Shallow groundwater sources and unconfined aquifers under the influence of surface water are very susceptible to contamination from nonpoint source pollutants. Since water and pollutants travel easily between surface waterways and shallow aquifers, pollutants originating in the headwaters of a watershed can make their way to wells farther downstream. Therefore, shallow groundwater sources and unconfined aquifers need to be protected in a similar manner to that of surface water sources, through the protection of forests, wetlands, small streams, and high-yield recharge areas.

CASE STUDY

Orange Water and Sewer Authority, Carrboro, North Carolina

The University Lake Watershed is an important drinking water source for residents of Carrboro, Chapel Hill, and the University of North Carolina at Chapel Hill. These communities, as well as 90 percent of the watershed, are located within Orange County, which has experienced significant growth during recent decades. By the late 1980s it was clear that, unless more carefully managed, continued growth could have a serious effect on the safety and availability of water in University Lake.

In response to this growing threat, Orange Water and Sewer Authority (OWASA) initiated a planning process with the four governmental units that had planning and zoning jurisdiction within the watershed (Orange County, Chatham County, and the Towns of Carrboro and Chapel Hill). The goal was to develop a joint source water protection agreement that incorporated a variety of voluntary and regulatory landuse tools.

A committee of elected officials from each jurisdiction negotiated a protection plan that met the interests and needs both of the residents in the watershed and the consumers of the drinking water. After two years of negotiation, water quality modeling, and extensive public outreach, the committee developed an agreement that was politically viable and technically justified in all of the affected communities. This agreement creatively used a variety of regulatory tools, including minimum lot sizes, limits on impervious surfaces, the prohibition of public sewer extensions into the watershed, and the potential for the transfer of development rights between zones in the watershed.

During the negotiation process, it became

clear that regulatory strategies alone would not be viewed as equitable by all communities in the watershed. Rural watershed residents were perceived to be bearing the brunt of the protection measures through down-zoning of their properties, without receiving any of the benefits, as they did not drink the water from the lake and, under the protection plan, could not receive sewer services.

In response, a land acquisition fund was created to redirect some of the resources from the communities that would benefit from the cleaner water—primarily Carrboro and Chapel Hill—to the rural communities in the watershed. Rural landowners could choose to sell their properties at fair market value or sell the development rights, rather than lose value to down-zoning. OWASA created a line item in their Capital Improvements Budget that authorized spending a percentage of revenue each year to purchase sensitive lands. Since its inception in 1991, the fund has spent $4 million on acquisitions and easements and leveraged that investment to attract an additional $1.7 million in grant funds from the North Carolina Clean Water Management Trust Fund.

CONTACT: Ed Holland, Planning Director
ADDRESS: Orange Water and Sewer Authority, P.O. Box 366, Carrboro, NC 27510-0366
PHONE: 919-537-4215
FAX: 919-968-4464
EMAIL: eholland@owasa.org
WEB SITE: http://www.owasa.org

CASE STUDY

San Antonio, Texas

The San Antonio Water System (SAWS) serves approximately 1.1 million customers via 92 wells that draw from Edwards Aquifer. In 1975, it was the first aquifer in the United States to receive a sole source designation by the EPA.

In a May 2000 bond measure, San Antonio voters approved a one-eighth cent sales tax increase for land acquisition to protect the Edwards Aquifer and to create greenways along sensitive creeks within the city. This measure raised approximately $65 million over the next four years. Of the four bond measures on the ballot in 2000, including measures to increase tourism and attract new businesses, the water quality measure was the only one approved by San Antonio voters.

Years of public education efforts by the San Antonio Water System had laid the groundwork for the measure by educating residents on water supply issues within their community. But the impetus and popular support necessary to pass the bond measure came from grassroots efforts to mobilize voters and educate the public about the threat to their water supply brought by rapid development within the aquifer's recharge zone.

SAWS initiated its sensitive Land Acquisition Program (LAP) in 1997 specifically to protect and preserve the quality and quantity of water in the aquifer recharge zone. The program protects lands that are predisposed to geologic sensitivity and possible contamination, such as point recharge features (caves, solution cavities, and sink holes). Criteria used to determine eligibility for acquisition include maximum thickness of Edwards limestone on the property; presence of streams or rivers; presence of faulting; presence of major features; and availability and affordability of the property.

Funding for the LAP is allocated through a portion of the Water Supply Fee. Since 2000, SAWS and its partners have preserved over 10,000 acres of land, at a cost of over $5.6 million. The cost to SAWS was just $1.8 million, as it effectively leveraged its funding with funding from the city, state, and private funding sources.

The Trust for Public Land, The Nature Conservancy, Texas Parks and Wildlife, and the Bexar Land Trust are working as a team with SAWS to protect and manage these lands. Texas Parks and Wildlife took title to one of the first major acquisitions, Government Canyon, creating Government Canyon State Natural Area. Land for this first acquisition came from more than a dozen public agencies and private groups. The Trust for Public Land, The Nature Conservancy, and the Bexar Land Trust work cooperatively with landowners to negotiate and contract for many of the fee and easement acquisitions and, in some cases, to help with ecological inventories and land management strategies.

CONTACT: Kirk Nixon, Manager
ADDRESS: San Antonio Water System, 1001 East Market Street, San Antonio, TX 78298
PHONE: 210-704-7305
EMAIL: knixon@saws.org
WEB SITE: http://www.saws.org

"Our watershed is on the central coast of New Jersey, where the soils are sandy and water can travel underground about 150 feet per day," notes Steve Specht with the Brick Municipal Utility Authority. "We draw our drinking water from both surface and groundwater sources, but with 70 percent of the river water coming from the ground, we know our surface and groundwater resources are one and the same. We're actively working with the state, counties, and surrounding communities to protect the wetlands in our headwaters. We believe this is one of the main reasons our water quality is still good, despite increased development upstream."[66]

PART TWO

BEST PRACTICES

With the national rate of land development increasing twice as fast as population, communities need to be proactive about protecting natural resources, particularly their source of drinking water. Although investments in maintaining and upgrading treatment systems will always be critical to protecting public health, these remedial approaches need to be balanced with investments in source protection. Communities that invest in land protection as a way to protect their drinking water are investing in the long-term health and quality of life of their citizens—guiding growth away from sensitive water resources, providing new park and recreational opportunities, protecting farmland and natural habitat, and preserving historic landscapes.

The emphasis on source protection has changed over time and continues to evolve. The congressional mandate for state Source Water Assessment Plans (SWAPs) in the 1996 amendments to the Safe Drinking Water Act provided a critical national focus on watershed health as a component of preserving safe drinking water. SWAPs are a comprehensive initiative designed to inform communities about the location of their drinking water resources and about threats to their water's quality and quantity in order to encourage and assist local protection activities, including land conservation. The call for SWAPs acknowledged the increasing challenges and costs facing public water systems, and the value of promoting source protection as part of a multiple-barrier approach.

Though not mandated, public water suppliers and local communities are now expected to develop management measures to protect their drinking water sources. Armed with data from their SWAP process, many communities are now focusing on watershed management issues, including landuse planning, public education and outreach, land management, and conservation. Yet the tools, best practices, funding, and partnership for implementation are currently limited. Networks for sharing information are only just developing via efforts by the Environmental Protection Agency, American Water Works Association, National Rural Water Association, Association of State Drinking Water Administrators, and others.

The series of best practices and case studies outlined here are designed to fill this gap, offering suppliers and municipalities a set of guidelines and funding strategies for using land conservation as part of a comprehensive approach to source water protection. The following five best practices provide a framework for developing and implementing a source protection plan. They can guide city planners, government officials, and water suppliers through a process that begins with developing a comprehensive understanding of landuse threats to drinking water and leads to funding actual land protection strategies.

The best practices we explain here are:

1. Understand your watershed
2. Use maps and models to prioritize protection
3. Build strong partnerships and work watershed-wide
4. Create a comprehensive source protection plan
5. Develop and implement a "funding quilt"

The Trust for Public Land has also produced a companion report, *Source Protection Handbook: Using Land Conservation to Protect Drinking Water Supplies*, which provides detailed guidance on how to implement each of the best practices presented. Copies of the handbook can be ordered from TPL's Web site, *www.tpl.org*.

Best Practice: Understand your watershed

An understanding of your watershed and aquifer recharge areas is the foundation upon which an effective source protection plan is built. Such an understanding involves the collection and analysis of scientific data about source lands, landown-

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The rapidly growing population in the vicinity of Florida's Indian River Lagoon, an estuary stretching more than 150 miles down the East Coast, is expected to reach nearly one million by 2010. Efforts to protect the area's water quality through land acquisitions have been underway since the 1970s.

ership, growth and development patterns, and the health of watershed lands. Scientific data and watershed analyses are essential to define an effective source protection plan and build public support for its implementation. That's because zoning and other public policy changes need to be both technically and legally justifiable, and they require political support from elected officials; land conservation strategies, although voluntary, require public support and usually the commitment of public funds.

In many watersheds and aquifer recharge areas, water quality data is being, or has been, collected by more than one organization, and watershed analyses have been conducted at the local, state, or federal level. Often, these varied sources of information have not been brought together into one source water assessment. The first step in understanding your watershed is to compile existing information in order to understand the current and likely future threats to your drinking water.

Comprehensive water quality monitoring is another key to understanding watershed health and tracking the impacts of changing landuse on water quality. Monitoring is a technical process that can help you understand the fundamental health of your watershed, where landuse is impacting water quality, and where conservation, restoration, or best practices are effectively mitigating those impacts.[67]

A comprehensive monitoring program should include (1) sampling on all major tributaries throughout the watershed, (2) sampling at targeted sites to test the impacts of specific landuse activities, (3) physical, chemical, and biological sampling methods, and (4) monitoring during both wet and dry weather.[68] A monitoring program should be implemented consistently across all jurisdictions in the watershed in order to establish a baseline of past and current watershed health and to document the impact on water quality from changes in landuse or management.

In most watersheds, multiple organizations have collected data at different times. This data can be consolidated and analyzed as a single resource. An analysis of existing data that is physically and conceptually accessible to the public, elected officials, and other stakeholders will help create a shared understanding of current and future threats to water resources and can lead to a shared commitment to action.

"If you don't understand the baseline and normal water quality range in your source area, you have no way to identify where landuse is impacting water quality and where restoration or best practices are effectively mitigating those impacts," says Chris Crockett with the Philadelphia Water Department. "In every other industry, the raw materials are so important they are tested repeatedly to ensure the quality of the final product. Water treatment needs to be approached similarly by creating comprehensive monitoring programs that effectively track the quality of water throughout the source area."[69]

Although there will always be a need for ad-

ditional data, improved analysis, and better data collection methods, waiting until every outstanding question is answered can stall valuable implementation strategies to address known threats. "We found that although it is important to continuously improve our understanding of the watershed and the threats to our drinking water, it is equally important to begin acting on the information we have," explains Carol Storms, Manager of Water Quality with New Jersey American Water.[70]

CASE STUDY

Philadelphia Water Department, Pennsylvania

The Philadelphia Water Department (PWD), which provides drinking water to 1.5 million people, draws its water from three drinking water intakes in the Delaware River Watershed, which drains from 13,000 square miles of land stretching from Pennsylvania and New Jersey all the way to New York state. This extremely complex watershed incorporates dozens of urban areas throughout the mid-Atlantic, such as Philadelphia and Trenton.

Despite the size and complexity of its watershed, the Philadelphia Water Department has been proactive about finding out what is in their source water, where it is coming from, and how they and their partners can mitigate pollutant loads throughout the watershed. Philadelphia is on the cutting edge of identifying, monitoring, understanding, and treating emerging contaminants. Chris Crockett, manager of Philadelphia's Source Water Protection Program, says,

> The balancing act is, how do we stay at the front edge of emerging contaminants and prepare for the future without overreacting to something or wasting resources? Our strategy is to (1) identify potential sources of contamination from monitoring data, landuse information, and literature review; (2) determine the future potential impact of those sources on treatment, public health, and aquatic life; (3) identify what existing practices can be used to address this future threat; and (4) determine what amount of resources will be needed. Our systematic approach to understanding and addressing emerging threats helps us target our resources most effectively.
>
> For example, if monitoring data and literature reviews point to antibiotic-resistant bacteria or pathogens from animals as a growing threat in particular sub-basins, we look for ways to increase our stream bank fencing and manure management techniques, which we know are effective at keeping those contaminants out of the water. It gets more complicated when we look at pollutants such as endocrine disruptors and pharmaceutical residuals from humans, because even if we could estimate loadings through monitoring and modeling, there is limited knowledge of public health impacts and no water quality standards to guide our remediation efforts. But just knowing the pollutant is there and understanding its source is critical to protecting public health.[71]

The Philadelphia Water Department works with governmental and nonprofit partners to collect monitoring data throughout the watershed to measure pollutant loads, identify potential sources, and develop strategies for addressing those sources. Their partnership with the Schuylkill Action Network is an example of this process in action. The partnership includes over 200 stakeholders, from community and watershed groups to regulatory agencies. PWD provides technical coordination and planning to the network by compiling information on water quality, stream impairment, landuse, source activities, compliance, funding and protection activities, and data analysis in order to prioritize areas for restoration and protection. Stakeholders then review the information to determine the actions necessary to address priority sites and how they can be integrated effectively with existing initiatives. By working collaboratively, they address multiple stakeholder objectives and bridge Clean Water Act and Safe Drinking Water Act goals.

CONTACT: Chris Crockett, Manager, Source Water Protection Program
ADDRESS: Philadelphia Water Department, 1101 Market Street, 4th Floor, Philadelphia, PA 19107
PHONE: 215-685-6234
FAX: 215-685-6043
EMAIL: chris.crockett@phila.gov

Best Practice: Use maps and models to prioritize protection

Municipal water supply managers and conservation agencies routinely face questions and problems when ranking conservation and restoration priorities. Which forested parcels should receive the highest priority for conservation? Which areas are in need of restoration using creekside forest

buffers? Where will storm water management practices likely yield the greatest improvements in water quality? Identifying high-priority land for protection and restoration is critical, as funding is always limited and multiple demands often are made on a valuable piece of land.

A number of characteristics make some lands more important to protect or restore than others. Parcels with steep slopes and erodable soils, in forest or other natural cover, and close to a waterway or encompassing small streams are the most critical to protect; development on these sites is more likely to degrade water quality. Geographic Information System (GIS) maps and models can be very helpful in identifying these critical parcels and showing where protection or restoration will have the greatest benefit for water quality. GIS software can be used to identify high-priority lands in a number of different ways, including:

- Identifying landuse and features (such as streams or slopes), or locating parcels of land or contaminants using existing data sources.
- Creating ranking systems and operational models that rank parcels based on a set of characteristics. These models require digitized data layers for the characteristics of greatest interest, such as slope, land cover, and distance to stream.
- Developing quantitative models that can predict potential impacts from landuse on water quality, such as pesticide concentration, nutrient loading, or total suspended solids in stream water. These models require long-term, research-grade weather, streamflow, water quality, and watershed data for development, testing, and validation.

As our understanding of the impacts of landuse on water quality improves and the GIS mapping software becomes more sophisticated and accessible, prioritizing areas in a watershed is becoming more feasible even for communities with limited resources and technical capabilities. The simplest use of GIS—mapping landuse, municipal, or parcel boundaries, or locating contaminant sources—can be very helpful in integrating information into one watershed map that can become a shared resource and guide for remediation or protection. For small communities with limited resources, this can be an excellent first step in understanding threats to drinking water and mapping out a strategy for protection. For more information on how to create such a tool, see *Using Technology to Conduct a Contaminant Source Inventory: A Primer for Small Communities*, a publication by the Groundwater Foundation (www.groundwater.org).

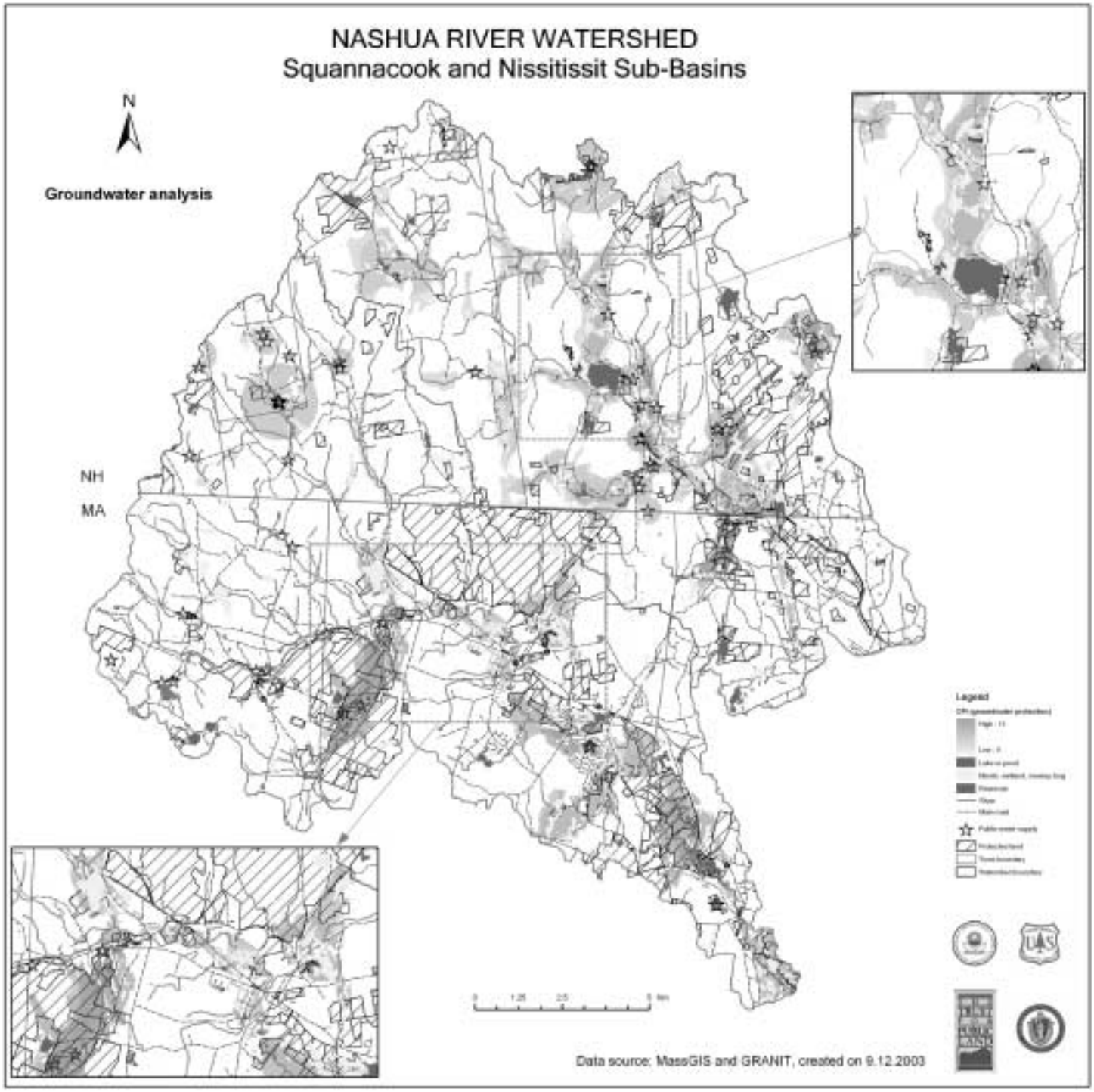
Complex GIS applications, such as quantitative models that predict impacts on water quality from landuse change, can be very useful and accurate. Yet they require more significant resources, technical expertise, and data than many communities may have. Environmental consulting companies are excellent resources in thinking through whether and what quantitative models are the most appropriate tools for reaching your goals.

Ranking systems, which are easier to implement than quantitative models, are a widely used GIS tool for identifying high-priority areas for protection and restoration. Ranking systems combine information on land characteristics such as soil type, slope, landuse, and zoning, ranking each characteristic in importance. For example, a large forested parcel that encompasses small streams with steep slopes and highly erosive soils would rank higher for protection or restoration than a level parcel with good soils that is far from a water source. Where digitized parcel data is available, each parcel can be given a numeric score indicating its value for conservation or restoration. Ranking systems can efficiently generate land protection priority lists. When combined with local knowledge and field inspections, the resulting priority lists are accurate and effective decision-making tools. For more information on creating a GIS-based ranking system for your watershed, see the *Source Protection Handbook: Using Land Conservation to Protect Drinking Water Sources.*

The EPA's Southeast Regional Office has developed a Watershed Characterization System that provides a wealth of information for organizations operating in the Southeast. This software incorporates extensive state-level data on landuse, soils, slope, and water quality, all of which can be used for targeting on-the-ground strategies.

Some communities have combined GIS-based ranking systems with other analyses, such as cost-benefit. For example, Orange County Water and Sewer Authority, working in partnership with Tetra Tech, Inc., has developed an efficient and cost-effective way to prioritize parcels for acquisition by using formulas to estimate potential phosphorous loads from future development at each site, and then weighing phosphorous loads against the cost for either acquisition or easements. This strategy allows them to identify the parcels with the greatest potential phosphorous load and the lowest cost, which are highest priority for protection.

For more information on the many ways GIS can be used, refer to *Conservation Geography: Case Studies in GIS, Computer Mapping, and Activism*.[72]



Groundwater Conservation, Restoration, and Storm Water Management Priority Indices for the Squannacook and Nissitissit River Watersheds, Massachusetts and New Hampshire. The enlarged areas are centered on (left) Townsend, Massachusetts, and (right) Brookline, New Hampshire. Conservation Priority level was based on whether forested or wetland, type of soil, transmissivity, and whether there is a public water supply. This map includes all Community Water Systems with more than 25 users, with Zone I and Zone II source protection areas in gray.

CASE STUDY

Nashua, Massachusetts

The Nashua River Watershed extends through 31 communities in northeastern Massachusetts and southern New Hampshire. The Squannacook and Nissitissit sub-basins make up the northern portion of the Nashua Watershed, where it crosses the state borders. These sub-basins comprise approximately 133 square miles and include portions of four counties, two states, and five towns in Massachusetts and six towns in New Hampshire. They are primarily rural and forested and have been recognized for their pristine water and important and unique habitat. There are approximately 12 community water systems in the Squannacook and Nissitissit sub-basins, all of which draw their water from wells.

The Nashua River Watershed Association (NRWA), which has been working since 1969 to protect and improve the ecosystem of the Nashua River Watershed, recognized that protecting drinking water sources was critical to the health of the watershed community, and that source protection strategies could effectively strengthen and support their broader clean water and habitat goals. In 2001, the NRWA applied to participate in an EPA-funded demonstration project to study the Squannacook and Nissitissit sub-basins and identify ways that land protection and management strategies could be used to protect drinking water sources.

As part of this demonstration effort, the University of Massachusetts produced maps that identified areas of the watershed that were highest priority for conservation and restoration. Because all of the communities in the Squannacook and Nissitissit sub-basins drink groundwater, maps and models were developed that combine data on groundwater wells, soils, slope, landuse, and pumping rates to identify the highest priority lands for protecting and improving groundwater. The Nashua map shows in gray areas of the watershed that are high priority for conservation, with highest priority areas in dark gray. Recharge areas for groundwater wells ranked high, along with areas with shallow groundwater under the influence of surface water. Similar maps were produced to identify high-priority areas in the watershed for the protection of surface water supplies.

By overlaying parcel lines, the NRWA is able to identify individual landowners whose property is critical to the quality and quantity of groundwater supplies. Using these maps, NRWA staff is conducting outreach to landowners to discuss options for participation in state forest stewardship programs, which offer tax breaks for implementing forest management plans, and ways that landowners can conserve their property through state and federal easement and cost share programs.

CONTACT: Al Futterman
ADDRESS: Nashua River Watershed Association, 592 Main Street, Groton, MA 01450
PHONE: 978-448-0299
EMAIL: alfutterman@nashuariverwatershed.org
WEB SITE: http://www.nashuariverwatershed.org

Best Practice: Build strong partnerships and work watershed-wide

Effectively implementing a source protection plan requires the support and cooperation of a variety of public and private partners. That's because most communities' source areas lie partially, if not entirely, outside of their jurisdiction and, in most cases, cross multiple jurisdictions and even state lines. And although few suppliers have the authority to directly control activities on land in their source area, most have the ability to plan and partner with other communities and stakeholders who can directly influence landuse and land management. Source water protection can be achievable and effective when you influence others to act on your behalf, utilize existing initiatives and frameworks, and find common goals with others to build partnerships.[73]

Potential pollution sources must ultimately be managed at the local level, where most landuse decisions are made. Partnerships can be built with local jurisdictions, nonprofits, and other stakeholders by identifying common goals and planning ways to achieve them together. Farmers benefit from clean water for cows in order to reduce disease. Recreational users benefit from improved fish habitat and safe swimming opportunities, and upstream townships might benefit by meeting obligations for existing regulatory initiatives, such as Phase II Storm Water Regulations or Total Maximum Daily Loads, or simply by improving local quality of life.[74] "We have found that sometimes simply finding a way to help a partner address a nagging local issue can make a project successful," notes Crockett.[75]

When thinking about who needs to be involved in a source protection planning process, the key is to consider who will ultimately be needed to successfully implement a plan. "Too often we count the success of a planning effort based on how

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A coalition of groups is working to protect a 180-mile greenway along the banks of Georgia's Chattahoochee River from development pressures. The river provides drinking water to half the state's population.

many people were at the table, particularly how many residents or members of the general public showed up to our meetings," says Billy Turner, director of the Columbus Water Works. "Instead, we need to think about what our ultimate goal is and who will be needed to implement that goal once the planning has ended."[76]

It may not be clear at the beginning of the process exactly who will be needed for successful implementation, but it will be clear that:

- *Local*, *state*, and *federal* funding will be needed.
- *Landowner groups* will be important, such as farmers, developers, and woodlot owners, if nonpoint source pollution is the primary threat.
- The *municipalities* that reside in the watershed or manage the local water supply will ultimately have to implement regulatory changes or fund acquisition.
- *Business and industry groups*, which may contribute to water quality problems, need to be part of finding solutions. Their early substantive involvement is critical to developing successful and broadly supported protection strategies.
- If supplies are managed privately, those *suppliers* can be involved in funding and implementing strategies to protect their source.
- *Local land trusts, watershed associations, and other nonprofits* can be key to public outreach and education and, potentially, to implementing strategies with their constituent groups.

Other jurisdictions and stakeholders will often support and contribute to source water protection efforts that meet their goals and objectives and that build on initiatives they already have under way, if the information they need to guide their actions is made available to them. Most watershed and community organizations, and even some municipalities, lack the technical knowledge or resources to direct their activities at the highest priority needs. Stakeholder relationships can be developed through the exchange of data, maps, or other technical or scientific information. If the utility or municipality does not have the capability to provide this data themselves, they can work with other municipalities, local colleges, planning commissions, or river basin commissions to help them create the needed resources.[77]

Although local municipalities and suppliers play an important role in coordinating source protection efforts, federal and state governments and nongovernmental organizations (NGOs) play critical roles in planning, financing, and implementing source protection strategies. Involving state and federal representatives in source protection planning facilitates the local communities' access to additional data, funding sources, and technical assistance, all of which contribute to successful implementation.

In some source areas, voluntary watershed associations and other NGOs are beginning to take on the role of coordinating entities. As independent third parties, they can often bring together local municipalities and counties that may not have planned cooperatively in the past and help them to plan for the protection of regional resources. Nongovernmental organizations often bring unique skills and organizational flexibility that can leverage new resources and encourage new strategies.

CASE STUDY

Columbus, Georgia

Columbus Water Works (CWW) is in its final year of a three-year program studying water quality in the Middle Chattahoochee River Watershed. The study is an effort to assess total maximum daily load (TMDL) allocations through the calibrated Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) developed in the Middle Chattahoochee study. This work will help provide communities with assistance in their regulatory and stewardship programs, including source water assessment and protection.

CWW serves approximately 200,000 customers in an estimated 74-square-mile area on the river about 120 miles southwest of

Atlanta. The river segment in this study area divides Georgia from Alabama and encompasses the growing cities of LaGrange, West Point, and Opelika. Metropolitan Columbus, located in the center of the study area, is growing within the core areas of the drinking watershed. A key feature of this study is CWW's initiative in testing the idea of interstate water resource coordination with the creation of a stakeholder team that includes seven water companies, Georgia Power, Natural Resources Conservation Service, local universities, the Chattahoochee River Keeper, and state and federal agency representatives.

While CWW has primary responsibility for the Combined Sewer Overflow (CSO) control, the comprehensive watershed study was approached as a partnership venture. The stakeholders are working together with CWW consultants, the EPA, and the Water Environment Research Foundation (WERF) on the watershed study. They are coordinating a monitoring network and an Internet-based GIS information and communications network; discussing and implementing source water protection policies; and integrating drinking water source protection with other regional goals for recreation, tourism, and economic redevelopment.

In 1993, CWW developed a vision, "to be the nation's best water resources utility by 2000," and it made significant progress toward that goal through its multi-jurisdictional partnership and aggressive public outreach efforts. In the early 1990s, the citizens of Columbus were faced with significant increases in water/wastewater rates to rehabilitate the CSO system to meet state requirements. Voters overwhelmingly supported a 1 percent special local option sales tax to underwrite the cost of the CSO program as well as a number of associated community projects.

CWW used the funding to implement the CSO plan and to foster a comprehensive public education initiative to develop and nurture a long-term commitment to protecting drinking water supplies. The Oxbow Meadows Environmental Learning Center, the crown jewel of the outreach initiative, provides environmental education to a broad spectrum of users and visitors. Two new treatment facilities were developed with dual-use community features such as the 8.2-mile Riverwalk and a two-block city park built over one of the treatment plants. These strategies provide both recreational amenities to residents and needed treatment facilities.

The total cost of the CSO control program and parallel community projects like the Riverwalk was $95 million. Between 1997 and 1998, CWW's total assets increased more than $100 million to $382 million. During the same time period, the operating budget reflected a $1 million decrease from the previous year's budget of nearly $14 million, due to numerous managerial and operational improvements. More importantly, Combined Sewer Overflow events monitored since the fall of 1998 have demonstrated consistent compliance with water quality standards for the river.

CONTACT: Billy Turner, Director
ADDRESS: Columbus Water Works, P.O. Box 1600, Columbus, GA 31902
PHONE: 706-649-3430
FAX: 706-327-3845
EMAIL: bturner@cwwga.org
WEB SITE: http://www.cwwga.org

Best Practice: Create a comprehensive source water protection plan

Creating a comprehensive source water protection plan is an opportunity to pull together everything learned from analyzing a watershed, assessing the threats to drinking water, mapping high-priority land for protection and restoration, and developing partnerships. Such a plan should be developed with other partners and jurisdictions in a source area and should incorporate the following:

- *Strategies for managing threats, such as wastewater and agricultural runoff, and for protecting natural resources, such as forests and wetlands.* In most drinking water watersheds, threats to water quality exist from septic systems, agriculture practices, lawn maintenance, underground storage tanks, and other point and nonpoint sources of pollution. Source water protection plans should identify the greatest threats and outline a plan to manage those threats in the future. Likewise, identifying and protecting highly sensitive lands that are vulnerable to development allows communities to be proactive about protection and avoid costly mitigation or restoration action in the future.
- *A combination of voluntary and regulatory strategies, such as land acquisition and landuse regulation.* A comprehensive source water protection plan should combine voluntary and regulatory strategies, along with best management practices. Landuse regulations should be balanced with voluntary acquisition and

cost-share programs in order to be politically viable and effective over the long term. "No single management option can meet all of our source water protection objectives; therefore, a combination of methods is needed," according to Ed Holland with Orange Water and Sewer Authority in North Carolina.[78]

- *A long-term vision, short-term action strategies, and measurable goals.* Plans are only as valuable as the actions that result from them. Therefore, a long-term vision (extending as far as 30, 50, or even 100 years) should be accompanied by short-term action strategies. Such action strategies should be feasible and their results measurable, with timelines, budgets, and critical partners identified, so that as funding becomes available or opportunities arise, they can be acted on.
- *A strategy to fund the plan.* Funding can come from a wide variety of sources that change regularly, depending on the political and financial climate. Potential funding sources that are identified up front can be pursued when the time comes. Look for both existing funding sources and new sources created through public finance measures, fees, or other strategies.

"Start your plan early and stick with it," advises Suzanne Flagor, director of Watershed Management with Seattle Public Utilities. "The key to Seattle's success in protecting our watershed was in having a long-term plan and taking advantage of opportunities to make progress on that plan as they arose. Funding availability and land ownership change regularly, creating unique opportunities for action. If you are not prepared to take advantage of those opportunities, they'll be lost."[79]

CASE STUDY

Seattle, Washington

In the late 1800s, residents in the small, coastal city of Seattle, Washington, were drawing their water from a series of wells, springs, and private water companies dispersed throughout the city. In 1889, the Great Seattle Fire, which destroyed the entire 64-acre business district, exposed the glaring inadequacies of the city's water supply system, which had insufficient water or water pressure to suppress the blaze as it raged through town.

Immediately after the fire, residents voted to create a city-owned and -operated water system. A bond was passed within a year to purchase two water companies. By 1895, voters again approved bonds to construct the Cedar River system, in the mountains outside of town, which continues to be Seattle's primary water source today.

Shortly after constructing the water supply system, city leaders agreed on a plan to eventually own the entire Cedar River Watershed, thus permanently protecting and securing Seattle's drinking water. With a 100,000-acre watershed, it was a bold vision, yet the plan was simple:

- Buy land, not trees.
- Invest in the future by planting seedlings.
- Manage the land for water and wildlife.

The city's first purchases were in 1898. At the time, the watershed was owned by homesteaders, timber and mining companies, and the federal government, all of whom were there to extract resources from the land. The city knew it was buying a "fixer-upper," but that was part of the plan. The city negotiated agreements with timber companies to allow them to harvest the trees and eventually sell the barren land to the city at incredibly low prices. Over the next 50 years, the city purchased almost two-thirds of the watershed through similar deals with private companies and individual landowners.

The remainder of the watershed was owned by the federal government, which is not permitted to sell land but can exchange it for land of equal or greater value. Over the course of 60 years, the City of Seattle purchased land in other parts of the state that they knew was high priority for the federal government, and they negotiated a series of land and timber exchanges that eventually led to the city's ownership of almost 100 percent of the Cedar River Watershed.

In 1996, the city's original vision, created over 100 years earlier, had finally been achieved. By strategically and creatively taking advantage of opportunities as they arose, and patiently sticking to a long-term vision, the City of Seattle has secured for its residents the permanent protection of one of the most pristine sources of drinking water in the country.

CONTACT: Suzanne Flagor, Director of Watershed Management
ADDRESS: Seattle Public Utilities, 19901 SE Cedar Falls Road, North Bend, WA 98045
PHONE: 206-233-1528
FAX: 206-233-1527
EMAIL: Suzanne.Flagor@seattle.gov
WEB SITE: http://www.cityofseattle.net/util/services/Drinkingwater

CASE STUDY

Austin, Texas

In 1998, the citizens of Austin, Texas, passed several bond measures for watershed protection and parks, officially launching the city's Smart Growth Initiative after years of grassroots advocacy. The Edwards Aquifer, on the western side of Austin, is the sole source of drinking water for over 1.5 million people, including residents of San Antonio and Austin. The Barton Springs segment of the aquifer—the segment around Austin—has been identified as the most endangered aquifer in Texas. It is highly vulnerable to pollution due to its relatively small size, its high porosity, and the region's land-development boom.

In 1995 and 1996, a Citizens Planning Committee studied landuse, transportation, and environmental concerns and developed the guiding principles for what in 1998 would become Austin's comprehensive Smart Growth Initiative. During the process, it was determined that the city's surface water needed protection beyond current regulatory restrictions. Building on that recommendation, the city council designated the most sensitive third of the Austin region—land that drains into Barton Springs and the Highland Lakes—a "Drinking Water Protection Zone." The remaining two-thirds were designated a "Desired Development Zone," which included the urban core, commercial corridors, and the central business district. This innovative landuse plan directed development away from sensitive groundwater recharge lands and toward targeted urban growth centers. This enhanced economic and neighborhood development strategies while protecting drinking water.

Even as Austin voters were trying to strengthen development regulations, they were also moving to protect the watershed through land acquisition. A 1991 poll jointly sponsored by the Trust for Public Land and Citizens for Open Space revealed that Austin residents favored open space acquisition—particularly as a means to protect water quality and secure recreation—and that they would approve increased property taxes to pay for the land. In 1992, they approved a $20 million bond act for a new Barton Creek Wilderness Park, which would protect the most critical areas around the springs.

Since 1992, Austin voters have chosen to spend over $200 million to protect their watershed. In 1997, after years of research, the city's Watershed Protection Department published *The Barton Creek Report*, which recommended further conservation through the purchase of land and development rights in order to protect drinking water quality. In 1998, voters approved several land-protection funding measures, including a $65 million revenue bond to purchase land and easements within the Drinking Water Protection Zone and a $75.9 million bond to create and improve parks and greenways, partly as incentive for attracting new development to the Desired Development Zone. Most recently, in November 2000, Austin voters once again taxed themselves, approving $13.4 million in bonding authority to protect land in the Barton Springs Watershed.

CONTACT: Butch Smith, Senior Planner
ADDRESS: Parks and Recreation Department, Municipal Building, 124 Eighth Street, No. 111, Austin, TX 78701
PHONE: 512-974-2000
FAX: 512-974-1886
EMAIL: butch.smith@ci.austin.tx.us
WEB SITE: http://www.ci.austin.tx.us

The Barton Creek Watershed protects the water quality of Edwards Aquifer, which is the sole source of drinking water for 1.5 million Texans.

Best Practice: Develop and implement a "funding quilt"

The implementation of a comprehensive source water protection plan requires a significant and steady stream of funds. Successful communities secure funds from a variety of sources—federal, state, local, and private—creating a so-called funding quilt. By tapping into a range of sources, communities can raise significant amounts of money and avoid reliance on a single, potentially unpredictable revenue stream.

On any specific project, a wide range of funding sources may combine to meet funding requirements, including a state grant matched by local funding; local funding that is supplemented by a private fundraising campaign; and a private conservation effort that leverages a federal grant. It is essential to use one funding source to leverage others.

Yet despite the importance of quilting together a combination of resources, local funding is the foundation of any long-term land conservation effort. Local funds allow for local control and demonstrate the commitment needed to leverage other resources. Explore all funding options, but always keep in mind that the largest burden rests with the local government.

This section outlines best practices for creating a source protection funding quilt. Included are guidelines specifically designed for local water suppliers and municipalities as well as broader state and federal frameworks. Only by understanding the conservation and source protection landscape at all levels is the full funding of local conservation projects possible.

CASE STUDY

Assawompsett Pond Complex, Massachusetts

Through a combination of state, local, and private funding sources, nearly 4,000 acres of the Assawompsett Pond Complex was protected in fast-growing southeastern Massachusetts. This collaborative effort included acquiring the 480-acre Betty's Neck property in Lakeville and securing conservation easements on 3,500 adjacent acres already held as municipal watershed land. The Assawompsett Pond Complex is the sole source of drinking water for the Cities of New Bedford and Taunton and provides drinking water to Lakeville. It is also home to an abundance of wildlife species and offers scenic beauty and recreational opportunities in the fastest-growing part of the state.

The majority of funding for this July 2002 project was provided by the state's Department of Environmental Protection Aquifer Land Acquisition Program, which made a $6.55 million grant and will receive a conservation easement on 3,500 acres. The state's funding came from the 1996 Environmental Bond Bill. The Town of Lakeville contributed $1.1 million and the City of New Bedford contributed $600,000 toward the Betty's Neck purchase. The City of Taunton hopes to receive $600,000 from the Statewide Revolving Fund for that purpose. The Trust for Public Land also contributed $250,000 to the project, thanks to an anonymous Boston foundation.

CONTACT: Badge Blackett
ADDRESS: TPL New England Regional Office,
33 Union Street, 4th Floor,
Boston, MA 02108
PHONE: 617-367-6200
FAX: 617-367-1616
EMAIL: Badge.Blackett@tpl.org
WEB SITE: http://www.tpl.org

Create and maintain dedicated local public funding sources

Local (preferably dedicated) funding is the foundation of any credible, long-term land conservation effort. The competition for state and federal funds is intense, and local funding is often necessary to secure these outside funds. Local funding is also the only source that is completely within the control of the local government, as federal and state sources are frequently subject to significant fluctuations that make them less reliable.

Local funding can take the form of a general fund appropriation or a legislatively approved tax increase. Often, however, the price tag, the politics, and the legal options warrant approval by voters of a conservation spending measure. Hundreds of local governments have passed ballot measures in recent years. During 2002 and 2003—two years of slumping economic fortunes—205 local governments across the United States passed ballot measures that included funding for land conservation. Seventy-five percent (in 2002) and 83 percent (in 2003) of local ballot measures placed before the voters passed around the country.[80]

The Trust for Public Land has worked with dozens of local governments to pass ballot measures, assisting with research and development,

public opinion polling, and ballot language design, and has compiled lessons learned regarding the key components to winning a land conservation measure. For more information on how to create a dedicated local funding source, see TPL's *Local Greenprinting for Growth Workbook, Volume III: How to Secure Conservation Funds*, which can be downloaded for free from TPL's Web site, *www.tpl.org*.

CASE STUDY

New York/New Jersey Northern Highlands

The Northern Highlands serve as the source of drinking water for 4.5 million people in New Jersey. The area includes a series of reservoir systems—the Wanaque/Monksville system, the Pequannock system, and the Boonton/Split Rock system. Over the past five years, within each system, a range of funding sources has come together to protect thousands of acres.

Several factors underpin the success in land conservation efforts in the Highlands. First, New York and New Jersey have significant state funding for land conservation—New York approved the $1.75 billion Clean Water, Clean Air Bond in 1996, and New Jersey's Garden State Preservation Act (1998) provides $98 million annually from the state sales tax. Second, New Jersey has provided the legal framework for counties and municipal governments to initiate local open space trusts and the incentives (via matching grants) to create them. As a result, all of New Jersey's 21 counties and more than 178 local governments have open space trust funds. Finally, there are broad networks of private foundations, land trusts, and citizen supporters of conservation in the area.

Local conservation finance measures have been approved in recent years in both Sussex and Morris Counties, home of the Pequannock and Boonton/Split Rock systems. Sussex County voters approved their first-ever property tax levy in November 2000, which raises $1.6 million annually, while Morris County voters increased their levy in November 2001 to $25 million to $30 million annually.

The Hawkwatch project in Rockaway Township, New Jersey, is an example of the local government funds helping to leverage other funding. Of the total $7 million for the project, Morris County and Rockaway Township contributed $1.5 million from their local property tax levies, and $3 million came from the state's Green Acres Program with a mix of grants and loans. An additional $1 million came from the federal Forest Legacy Program and the state grant portion of the federal Land and Water Conservation Fund, with more than $1 million from private foundations.

The most notable purchase within the Highlands was the 1998 purchase of 15,000 acres of Sterling Forest, a heavily forested area straddling the New York/New Jersey border. To reach the total cost of $55 million, Congress approved $17.5 million; the state of New York, $16 million; and New Jersey, $10 million. In addition, the Lila Acheson and DeWitt Wallace Fund for the Hudson Highlands and the Doris Duke Charitable Foundation contributed $5 million, while the Victoria Foundation contributed $1 million. Private donors provided the remaining funds.

CONTACT: Terrance Nolan
ADDRESS: Trust for Public Land, 20 Community Place, 2nd Floor, Morristown, NJ 07960
PHONE: 973-425-0360
FAX: 973-425-0366
EMAIL: terrance.nolan@tpl.org
WEB SITE: http://www.tpl.org

Create substantial state funding and the right mix of policies to support broad-based land conservation in a state

While landuse and land conservation activities are primarily the domain of local governments, the public policies established by state governments shape those decisions significantly. A good state framework for clean water and watershed management can give communities the flexibility, funding, and technical assistance they need to plan and implement successful programs.

States can promote source protection and clean water programs with incentives and funding programs that help local communities meet their watershed protection goals. States can play an enormous role in local watershed planning activities by putting forth an ambitious vision that captures complementary goals for land conservation and water quality protection. They can also provide key technical assistance with data collection and management, GIS mapping, build-out analysis, and landuse analysis.

A clear vision for source protection and clean water can lead to partnerships and leveraging of complementary federal funding, such as USDA's Natural Resources Conservation Service and Forest Legacy Programs. As public water suppliers and watershed planners create their funding quilt, states can help support these programs with clear

goals, blended funding streams, and program integration that matches the kind of integration happening locally. Some of the steps states can take to support local conservation for clean water are outlined below.

1. *Create substantial state investment.* A dedicated state funding source pays for statewide source protection projects and reinforces a long-term conservation commitment and vision. Some existing state programs rely on a single revenue stream, while others use a combination of revenue sources. The most common revenue streams used by states are general obligation bonds, sales tax, lottery income, real estate transfer tax or deed recording fees, and general fund appropriations.
2. *Enable and provide incentives for local financing.* State enabling legislation gives local governments the authority they need to raise local dollars. Incentives, often in the form of matching grants and low interest loans, encourage local governments and nonprofit conservation organizations to develop programs and generate local funds while strengthening partnerships.
3. *Leverage federal financing.* State grants and loans can be linked to federal Clean Water and Drinking Water State Revolving Funds to provide grants or low-interest loans for land conservation efforts that protect water resources.
4. *Link multiple community priorities.* State programs that link water quality benefits with other community goals, such as recreation, historic preservation, and habitat protection, will attract greater support and funding from the public and elected officials.

CASE STUDY

North Carolina

Following several high-profile water pollution incidents, in 1996 North Carolina's General Assembly created the Clean Water Management Trust Fund. The fund is the first state funding program in the country dedicated exclusively to water quality protection. It acts as a quasi-independent agency within the Department of Environment and Natural Resources, awarding grants to projects addressing water pollution problems.

Nonprofit land conservation organizations, municipalities, and state agencies have received grants supporting up to 100 percent of project costs. For example, in 1998, the fund granted rural Gaston and Lincoln Counties the full $6.15 million needed to buy 1,231 acres around Mountain Island Lake, key watershed land providing drinking water for more than a half-million Charlotte-area residents.

The Trust Fund has the option of requiring a 20 percent local match in funds. Projects must enhance or restore degraded waters, protect unpolluted waters, or contribute toward a network of buffers along riverbanks and greenways for environmental, educational, and recreational benefits. Uses for the funds include land acquisition, conservation easements, cooperative planning efforts, stream restoration, and wastewater and storm water projects.

The initial allocation for the program was 6.5 percent of the state's unspent fund balance, which came to about $45,000. Five years later, the allocation had grown to $30 million per year. And within the program's first decade, legislation requires the allocation be increased to $100 million.

CONTACT: Bill Holman, Executive Director
ADDRESS: North Carolina Clean Water Management Trust Fund, 1651 Mail Service Center, Raleigh, NC 27699-1651
PHONE: 919-733-6375
FAX: 919-733-6374
EMAIL: bill@cwmtf.net
WEB SITE: http://www.cwmtf.net

Use state-directed federal funds more creatively

Three distinct types of federal funding for land conservation exist:

1. State-directed programs, in which states receive grants from the federal government but are given broad discretion to allocate funds (Clean Water and Drinking Water State Revolving Funds)
2. Direct federal programs, in which the federal government makes direct grants in partnership with states to local recipients, usually local governments (Forest Legacy Program)
3. Direct federal acquisition (Forest Service or National Park Service acquisition)

The first category, state-directed federal programs, include the Clean Water State Revolving Fund (CWSRF), the Nonpoint Source Grant

Program (Section 319), and the Drinking Water State Revolving Fund (DWSRF). The revolving funds provide water quality improvement grants to states, which then make loans to local governments, and in some cases nonprofits, private citizens, and others. States are given a great deal of flexibility in the allocation and management of funds in order to encourage innovation and to allow them to address their most pressing water quality problems.

Traditionally, the CWSRF was used to fund new and upgraded wastewater treatment plants, and the DWSRF was used to fund new or upgraded drinking water treatment plants. Although there continues to be a need for capital improvements in many communities, the primary threat to water quality in most of our nation's waterways is no longer effluent from wastewater treatment plants but nonpoint source pollution. In fact, nonpoint source pollution now accounts for 60 percent of all pollution in U.S. waterways, yet 95 percent of CWSRFs go toward wastewater treatment upgrades.[81] Federal rules allow a great deal of flexibility in the use of the CWSRF, but the DWSRF rules only allow states to set aside up to 15 percent of their loan pool to fund land conservation or voluntary, incentive-based protection measures. This set-aside is too small to cover many land protection projects, ranked separately from other projects, and it is not integrated with other capital investments.

So how can states more effectively use their share of state-directed federal funds to address threats from nonpoint source pollution at the local level? The following best practices highlight what's working in many states.

1. *Create an integrated priority ranking system.* In order to fund a wider variety of high-priority projects, particularly nonpoint source projects, integrate Clean Water Act funding programs, including the CWSRF, the Nonpoint Source Grant Program, and the Estuary Program, and prioritize funding decisions based on primary water quality threats. In 2002, approximately 26 states took advantage of the flexibility in the Clean Water Act to create integrated priority ranking systems, including Minnesota, Oregon, and Washington. For more information on integrated priority ranking systems, refer to EPA's publication: EPA-832-R-01-002, March 2001.
2. *Allow private and public borrowing in the State Revolving Fund, Nonpoint Source Grant, and Estuary Programs.* Private borrowing by nonprofit land trusts and other groups can leverage private resources for water quality improvements. For example, a nonprofit can match a grant from an individual or foundation with an SRF loan to complete a conservation or restoration project. Over a dozen states allow private borrowing, including California and Illinois.
3. *Proactively promote the use of State Revolving Funds and Nonpoint Source Grant Program Funds for a wide variety of water quality projects, including land conservation and restoration.* Many potential borrowers do not know that federal rules allow these funds to be used for watershed protection or restoration, estuary management projects, and source water protection measures. State programs, such as Ohio's Restoration Sponsorship Program, have been very effective for promoting the use of funds for nontraditional projects.
4. *Provide state funding and mandates for implementing source water protection plans.* Currently there are no guidelines or provisions for implementing on-the-ground strategies, only a mandate to complete assessments. State funding or mandates could ensure that the effort that went into developing Source Water Assessment Plans results in actions to protect source waters.

Local stakeholders can also impact how federal conservation programs are structured and how funds are spent at the local level, particularly in the category of state-directed programs. Specifically, they can communicate with state program administrators about how these funds could most effectively address high-priority water quality problems. Generating applications for projects that address nonpoint source pollution and source water protection is another way to demonstrate local demand for NPS funding. And finally, local governments can encourage states to implement innovative grant and loan programs that leverage other local and state dollars. Where there has been a strong desire at the local level to use SRFs to fund nonpoint source projects, states have responded with creative loan structures and high funding levels.

CASE STUDY

Ohio's Restoration Sponsorship Program

With funding from the federal Clean Water State Revolving Fund (CWSRF) loan program, the Ohio Environmental Protection Agency has created an innovative program to address threats

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Northern Ohio's Edison Woods, located just south of Lake Erie, was permanently protected with funding from the Ohio EPA's Water Resource Restoration Sponsorship Program.

from nonpoint source pollution. Since its inception, Ohio's Water Pollution Control Loan Fund (WPCLF), which is funded through the federal CWSRF, has significantly reduced the impact of wastewater treatment on water quality. However, nonpoint source runoff and habitat degradation are impeding that progress and are threatening to reverse water quality improvements if not addressed.

Because of this growing threat, Ohio EPA officials are taking a broader perspective on water quality and how to protect and improve it. Rather than just looking at discharges from sewage treatment plants, they are looking at effects on water quality from storm water washing off roadways, loss of forested land to new development, and degraded stream corridors.

In 2000, the Ohio EPA created the Water Resource Restoration Sponsorship Program, which offers drastically reduced loan rates to utilities and local governments for traditional wastewater treatment work if the loan recipient either implements or "sponsors" a watershed protection or restoration project. "We're trying to get people to think more broadly to improve and protect water resources and at least to provide an incentive financially to encourage them to do that," said Robert Monsarrat, a manager within the Ohio EPA's division of environmental and financial assistance.[82]

Communities applying to the Water Resource Restoration Sponsorship Program for wastewater treatment loans can either implement their own watershed restoration project or sponsor a land trust, park district, or another entity's watershed protection or restoration project. The loan recipient receives a reduced rate for their loan equal to the principal and interest costs of the project, plus an additional reduction of 0.1 percent as an incentive. The savings they receive through the reduced interest rate is then granted to the watershed protection project. The result is the creation of new grant dollars for watershed protection projects and a total repayment cost for loan recipients that is lower than if they had borrowed solely for a wastewater project.

For example, if a utility borrows $1 million for a plant upgrade or expansion, they receive a standard interest rate of about 3.8 percent and have a total repayment of about $1,437,000, including principal and interest. If they borrow $1 million for a plant upgrade and an additional $393,000 for implementing a restoration or protection project, their interest rate would drop to 0.2 percent, resulting in a total loan repayment of $1,422,000—a savings of $15,000 on the total loan repayment. The utility can either use the $393,000 to implement the protection project themselves or grant it to a nonprofit partner to implement the project. Projects eligible for the Water Resource Restoration Sponsorship Program include the purchase of easements on riparian corridors, stream channel restoration projects, and wetland restoration and protection projects.

In the first two years of the program alone, communities used $24 million in loan funds to protect and restore 1,850 acres of riparian land and wetlands and 38 miles of Ohio's stream corridors. Efforts such as the protection of Sawmill Creek, the drinking water source for 400,000 Ohioans, and the protection of Edison Woods, a 1,300-acre reserve that is part of the National Estuarine Reserve System, illustrate the tremendous success of this innovative program in protecting and improving Ohio's valuable water resources.

CONTACT: Robert Monsarrat, Section Manager
ADDRESS: Ohio EPA, Division of Environmental and Financial Assistance, P.O. Box 1049, Columbus, OH 43216-1049
PHONE: 614-644-3655
WEB SITE: http://www.epa.state.oh.us/defa

In addition to state-directed programs, federal conservation funds are made available to state and local governments and to nonprofit organizations through appropriations, grants, and incentives. The Federal Funding Sources box below gives an overview of some of the most common federal funding programs for land conservation. Although none of these funding sources are directed specifically at source protection activities, many can be used for land protection strategies that protect source waters. Communities need to think creatively about how these funds can support their source protection goals.

Many of these programs require matching funds, underscoring the need to secure state, local, and private funds. Federal funds reach the local level in a variety of ways, depending on the program. Some funds are fully administered by state agencies; in others, the federal agency takes a more direct role. State agencies often provide information about federal funding sources, procedures, and contacts. For current and detailed information on federal funding sources for land acquisition, search TPL's Federal Programs at *www.tpl.org*. For detailed information on federal funds for all watershed protection activities use the EPA's online searchable Catalog of Federal Funding Sources for Watershed Protection at www.epa.gov/safewater/dwsrf.html.

CASE STUDY

Rockaway Township and Morris County, New Jersey

In Rockaway Township, New Jersey, funding from multiple sources reached a $7 million goal to protect local water resources. Local property taxes in Morris County and Rockaway Township contributed $1.5 million. The funding was supplemented by $2 million from the state's Green Acres program. The federal Forest Legacy Program and the state grant portion of the federal Land and Water Conservation Fund contributed another $2 million, and private foundations contributed more than $1 million.

Rockaway Township's success models how the presence of one funding source can help secure other funding. New Jersey's Department of Environmental Protection has successfully partnered federal Clean Water State Revolving Funds with state funding to finance the implementation of various water supply, wastewater, storm water, and nonpoint source pollution management projects through low-interest loans.

The U.S. EPA provides annual grants to states under a Clean Water State Revolving Fund. The money is generally used to provide

FEDERAL FUNDING SOURCES

Land and Water Conservation Fund (LWCF) is the largest source of federal money for parks, wilderness, and open space acquisition. The program's funding comes primarily from offshore oil- and gas-drilling receipts. At the national level, funds are used to acquire and protect new national forests, parks, wildlife areas, and other public lands. In FY 2002, Congress appropriated $429 million for specific acquisitions in these federal units. Stateside LWCF is a matching grant program that provides funds to states for planning, development, and acquiring land and water areas. In FY 2000, Congress reinstated funding for Stateside LWCF and funded it at $144 million in FY 2002.

Forest Legacy Program is administered by the U.S. Forest Service under its State and Private Forestry Division and provides matching funds to states to assist in forest protection. States may receive federal Forest Legacy grants of up to 75 percent of the total cost of the acquisition, with the remainder to be matched by nonfederal funds. In FY 2002, Congress appropriated $65 million for this program.

The North American Wetlands Conservation Act promotes voluntary public-private partnerships to conserve wetland ecosystems for waterfowl and other migratory birds. Acquired or restored habitat can be owned or managed by any federal, state, or nonprofit organization involved in land management. In FY 2002, Congress appropriated $43.5 million for this program.

The Cooperative Endangered Species Conservation Fund (Section 6 of the Endangered Species Act) provides matching grants to states for conservation projects that benefit not only species listed as endangered but also those that are candidates, or proposed for the list, on state, private, and other nonfederal land. In FY 2002, Congress appropriated more than $96 million for this program.

The Farmland Protection Program provides federal matching funds for state and local farmland protection efforts. To be eligible, a state, county, or local jurisdiction must have a complementary program of funding for the purchase of conservation easements. The 2002 Farm Bill provides $600 million over six years for this program.

The Transportation Efficiency Act for the 21st Century (TEA-21) provides states with funds to acquire land for historic preservation, trails, scenic beautification, and water pollution mitigation related to surface transportation through its Transportation Enhancements Program. The Recreational Trails Program provides funds for bike and pedestrian trails, and the Congestion Mitigation and Air Quality Improvement Program funds projects that improve air quality.

The City of San Antonio, Texas, in partnership with the Trust for Public Land, was awarded a $3.5 million grant by the U.S. Fish and Wildlife Service through the Habitat Conservation Plan Land Acquisition grant program, authorized under the Endangered Species Act (ESA). The grant will be used to protect land over the Edwards Aquifer Recharge Zone that provides critical habitat for nine federally listed endangered invertebrate species, as well as two endangered songbirds, the black-capped vireo and the golden-cheeked warbler. "This grant opens the door for the community to make critical additions to existing parkland, protect significant endangered species habitat and ensure clean drinking water for San Antonio and beyond," explains Jason Corzine with the Trust for Public Land.[83]

loans for wastewater treatment plants, but several states, including New Jersey, have used the money to help local governments and nonprofits purchase watershed land, restore watersheds, and reduce flooding. To qualify for the CWSRF, states must match federal funds with 20 percent of their own money. In addition to providing loans to public and private borrowers directly from the CWSRF, states have the option of pooling the grant money, from which bonds can be issued to augment funds available for projects.

New Jersey also revised its conservation funding selection criteria in 2002 so that projects with a water supply protection benefit receive three times the weight of other projects. Although the parcel must demonstrate water quality benefits, it does not have to be a drinking water source.

In the fall of 2000, the combined CWSRF and Green Acres funding program received 34 applications for the protection of 13,000 acres of land, for a total cost of $250,000. According to program managers, between 15 and 20 of those applications will probably be funded.

CONTACT: Terrance Nolan
ADDRESS: Trust for Public Land, 20 Community Place, 2nd Floor, Morristown, NJ 07960
PHONE: 973-425-0360
FAX: 973-425-0366
EMAIL: terrance.nolan@tpl.org
WEB SITE: http://www.tpl.org

Conclusion

The protection of source lands provides many benefits to a community: safe drinking water, natural resource protection, recreation amenities, and growth management. Local communities across the country are increasingly realizing such benefits, and source protection is gaining support once again as the cornerstone of the multiple-barrier approach to safe drinking water.

In fact, support for source protection is growing at all levels, from the passage of Safe Drinking Water amendments at the federal level that promote source water protection to state programs that encourage funding for nonpoint source protection projects, including land conservation. Yet public health and the delivery of clean, safe drinking water are ultimately local responsibilities that demand a committed, comprehensive, and sustainable response from water suppliers and local government.

Careful planning, leadership, and partnerships are essential. Local stakeholders must design and implement a publicly and politically viable plan to protect lands that provide critical drinking water supplies. This requires a complete understanding of the watershed and its threats, the identification and prioritization of key source lands, and the use of an array of conservation tools. To pay for the plan, local stakeholders should seek dedicated local funds that can leverage additional resources from federal, state, and private sources.

Local governments should also work with state and federal partners to improve and better integrate federal Clean Water and Safe Drinking Water programs and to increase their effectiveness at addressing nonpoint source pollution. Funding flexibility is the key: more creative uses of federal and state dollars, such as the Drinking Water State Revolving Fund and Section 319 of the Clean Water Act, allow local governments to secure more nonpoint source pollution funds for source protection.

Partnerships among federal, state, local, and private stakeholders extend beyond funding, providing opportunities to share essential planning data and expertise. Networks, partnerships, and resources are growing and should be utilized at every stage of the process. In many communities, innovative partnerships are also being forged with other local jurisdictions, landowners, watershed associations, land trusts, and a variety of nonprofit organizations.

Investments in watershed protection are becoming more a necessity than an option. State programs and local water suppliers support the notion that watershed planning and protection activities are key to a multiple-barrier approach. Voters support it too, with poll after poll showing support for new taxes for land conservation that protects water quality. At the federal level, the EPA supports many of these activities in principal, yet it can also work to enhance tools, promote new technology, and create more flexible funding options that help state and local programs make source protection activities a key focus in the multiple-barrier approach.

Glossary

Aquifer
An underground layer of rock, gravel, or sediment containing water. An aquifer may be confined between two impervious surfaces, or it may be unconfined.

Best Management Practices (BMPs)
Regulatory or voluntary procedures that can reduce the threat to water supplies posed by normal activities in homes, businesses, or farms.

Bioretention
A BMP that utilizes soils and both woody and herbaceous plants to remove pollutants from storm water runoff.

Emerging Contaminants
Diseases or chemicals that either are new to the environment or have been recently identified as potential health threats.

GIS Mapping and Modeling
Tools that enhance geography-related decision making. Maps and models are created from spatial and attribute data, and they are housed in a computerized Geographic Information System (GIS).

Nonpoint Source Pollution
Pollution that occurs when surface water runoff from rainfall or snowmelt moves across or into the ground, picking up pollutants and carrying them into streams, lakes, wetlands, or groundwater.

Pathogen
Any microbiological agent capable of producing disease in healthy peoples, plants, or animals.

Physical, Chemical, and Biological Monitoring
Three measurable components of water quality monitoring: Physical measurements may include temperature, flow, water color, and the condition of streambanks and lakeshores. Dissolved oxygen, suspended sediments, nutrients, metals, oils, and pesticides are examples of chemical measurements. The abundance and variety of aquatic plant and animal life are biological measurements.

Point Source Pollution
Pollution from a distinct, identifiable source, such as a feedlot or factory.

Purchase of Development Rights (PDR) and Easements
Agreement in which the residential, commercial, or industrial development rights of a particular parcel are transferred from landowner(s) to a different party. In most cases, *PDR* and *conservation easement* are interchangeable terms.

Riparian Zones
Vegetated areas abutting lakes, rivers, and streams that function as filters for polluted runoff, stabilize banks and channels, and provide habitat for fish and wildlife.

Total Maximum Daily Load (TMDL)
The amount of a particular pollutant that a stream, lake, estuary, or other body of water can contain without violating state water quality standards.

State Source Water Protection Contacts

ALABAMA

Joe Alan Power
Public Water Supply Branch
Alabama Department of Environmental Management
P.O. Box 301463
Montgomery, AL 36130-1463
PHONE: 334-271-7773
EMAIL: jp@adem.state.al.us

ALASKA

Sue Braumiller
Drinking Water Program
Alaska Department of Environmental Conservation
555 Cordova Street
Anchorage, AK 99501
PHONE: 507-269-3076
EMAIL: sbraumil@envircon.state.ak.us
WEB SITE: http://www.state.ak.us/dec/deh/water/protect.htm

ARIZONA

Mary Simmerer
Drinking Water Monitoring and Assessment Section
Water Quality Division, ADEQ
3033 North Central Avenue
Phoenix, AZ 85012-2809
PHONE: 602-207-4427
FAX: 602-207-4634
EMAIL: simmerer.mary@ev.state.az.us
WEB SITE: http://www.adeq.state.az.us/water/safe/swap.htm

ARKANSAS

Lyle Godfrey
Arkansas Department of Health
Division of Engineering
4815 West Markham Street, Mail Slot 37
Little Rock, AR 72205-3867
PHONE: 501-661-2623
FAX: 501-661-2032
EMAIL: lgodfrey@mail.doh.state.ar.us
WEB SITE: http://health.state.ar.us/eng/swpframe.htm

CALIFORNIA

Alexis Milea
Office of Drinking Water
California Department of Health Services
2151 Berkeley Way, Room 461
Berkeley, CA 94704
PHONE: 510-540-2177
FAX: 510-540-2152
EMAIL: hw1.amilea@hw1.cahwnet.gov
WEB SITE: http://www.dhs.ca.gov/ps/ddwem/dwsap/DWSAPindex.htm

COLORADO

Kim Parker
Colorado Department of Health and Environment WQCD-OA-B2
4300 Cherry Creek Drive South
Denver, CO 80246-1530
PHONE: 303-692-3582
FAX: 303-782-0390
EMAIL: kim.parker@state.co.us
WEB SITE: http://www.cdphe.state.co.us/wq/sw/swaphom.html

CONNECTICUT

Rob Hust
Connecticut Department of Environmental Protection
Water Management Bureau
79 Elm Street
Hartford, CT 06106-5127
PHONE: 860-424-3718
FAX: 860-424-4067
EMAIL: Robert.Hust@po.state.ct.us
WEB SITE: http://dep.state.ct.us

Lori Mathieu
Connecticut Department of Public Health
410 Capitol Avenue
MS#51 WAT
P.O. Box 340308
Hartford, CT 06134
PHONE: 860-509-7343
FAX: 860-509-7359

DELAWARE

John T. Barndt, P.G.
Water Supply Section
Division of Water Resources
Delaware Department of Natural Resources and Environmental Control
P.O. Box 1401
Dover, DE 19903
PHONE: 302-739-4793
FAX: 302-739-2296
EMAIL: jbarndt@dnrec.state.de.us
WEB SITE: http://www.dnrec.state.de.us/frames1.htm

FLORIDA

Donnie McClaugherty, P.G.
Water Standards and Classifications Section
Bureau of Water Resources Protection
Department of Environmental Protection
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, FL 32399-2400
PHONE: 850-921-9438
EMAIL: mclaugher_d@dep.state.fl.us

GEORGIA

Nolton Johnson
Water Resources Branch
Georgia Environmental Protection Division
East Floyd Towers, Suite 1362
205 Butler Street SE
Atlanta, GA 30334
PHONE: 404-651-5168
FAX: 404-651-9590
EMAIL: nolton_johnson@mail.dnr.state.ga.us
WEB SITE: http://www.dnr.state.ga.us/dnr/environ/pdfdoc/swappl12.pdf

HAWAII

Bill Wong
Safe Drinking Water Bureau
Hawaii Department of Health
919 Ala Moana Boulevard, Room 308
Honolulu, HI 96814
PHONE: 808-586-4258
FAX: 808-586-4370
EMAIL: waterbill@aol.com
WEB SITE: http://www.aloha.net/~will/hiswap.html

IDAHO

Lance Nielsen
Drinking Water and Waste Water Bureau
Idaho Division of Environmental Quality
1410 North Hilton
Boise, ID 83706
PHONE: 208-373-0502
EMAIL: lnielsen@deq.state.id.us
WEB SITE: http://www2.state.id.us/deq/Water.htm

Scott Short
Wellhead Protection Program
Idaho Department of Health and Welfare
Division of Environmental Quality
1410 North Hilton
Boise, ID 83706
PHONE: 208-373-0542
FAX: 208-373-0576
EMAIL: sshort@deq.state.id.us

ILLINOIS

Rick Cobb
Division of Public Water Supplies
Illinois Environmental Protection Agency
P.O. Box 19276
Springfield, IL 62794-9276
PHONE: 217-785-4787
FAX: 217-782-0075
EMAIL: epa3188@epa.il.us
WEB SITE: http://www.epa.state.il.us/water/source-waterassessment-and-protection/index.html

INDIANA

Lance Mabry
Ground Water Section
Indiana Department of Environmental Management
P.O. Box 6015
Indianapolis, IN 46206-6015
PHONE: 317-308-3318
FAX: 317-308-3339

IOWA

Dennis Alt
Iowa Department of Natural Resources
Wallace Office Building
900 East Grand
Des Moines, IA 50319-0034
PHONE: 515-281-8998

KANSAS

Jim Pennington
Kansas Department of Health and Environment
Building 283, Forbes Field
Topeka, KS 66620
PHONE: 785-296-5505

KENTUCKY

Jack Wilson
Division of Water
Natural Resources and Environmental Protection Cabinet
14 Reilly Road
Frankfort, KY 40601
PHONE: 502-564-3410
EMAIL: wilson_ja@mail.nr.state.ky.us
WEB SITE: http://water.nr.state.ky.us/dow/swap

LOUISIANA

Howard Fielding
Louisiana Department of Environmental Quality
Ground Water Protection Division
P.O. Box 82215
Baton Rouge, LA 70884-2251
PHONE: 225-765-0578
EMAIL: howardf@deq.state.la.us

MAINE

Paul Hunt
Maine Drinking Water Program
Bureau of Health, Division of Health Engineering
10 State House Station
Augusta, ME 04333-0010
PHONE: 207-287-6196
FAX: 207-287-4172
EMAIL: paul.hunt@state.me.us
WEB SITE: http://www.state.me.us/dhs/eng/water/swappage1.htm

MARYLAND

John Grace
Water Supply Program
Water Management Administration
2500 Broening Highway
Baltimore, MD 21224
PHONE: 410-631-3714
EMAIL: jgrace@mde.state.md.us
WEB SITE: http://www.mde.state.md.us/health/swap

MASSACHUSETTS

Tara Gallagher
Massachusetts Department of Environmental Protection
Drinking Water Program
One Winter Street
Boston, MA 02108
PHONE: 617-292-5930
FAX: 617-292-5696
EMAIL: tara.gallagher@state.ma.us
WEB SITE: http://www.state.ma.us/dep/brp/dws/dwspubs.htm

MICHIGAN

Elgar Brown
Ground Water Supply Section
Drinking Water and Radiological Division
Michigan Department of Environmental Quality
P.O. Box 30630
Lansing, MI 48909-8130
PHONE: 517-335-8312
FAX: 517-335-8298
EMAIL: BrownElg@state.mi.us
WEB SITE: http://www.deq.state.mi.us/dwr/swa/swa.htm

MINNESOTA

Bruce Olsen
Special Services Unit
Drinking Water Protection Section
Minnesota Department of Health
P.O. Box 64975
St. Paul, MN 55164-0975
PHONE: 612-215-0796
FAX: 612-215-0979
EMAIL: bruce.olsen@health.state.mn.us
WEB SITE: http://www.health.state.mn.us/divs/eh/dwp/swp/swp.pdf

MISSISSIPPI

Bill Wall
Division of Water Supply
Mississippi State Department of Health
2423 North State Street
P.O. Box 1700
Jackson, MS 39215
PHONE: 601-960-7518
EMAIL: billwall@mail.misnet.com

MISSOURI

G. Lawson Penny
Public Drinking Water Program
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, MO 65102
PHONE: 573-526-5449
WEB SITE: http://www.cares.missouri.edu/swap

MONTANA

Joe Meek / Russell L. Levens
SWAP Section, Pollution Prevention Bureau
Montana Department of Environmental Quality
Metcalf Building, Box 200901
Helena, MT 59620-0901
PHONE: 406-444-4806 / 0471
FAX: 406-444-1374
EMAIL: jmeek@mt.gov / rlevens@mt.gov

NEBRASKA

Marty Link / Stephanie Vap
Nebraska Department of Environmental Quality
P.O. Box 98922, State House Station
Lincoln, NE 68509-8922
PHONE: 402-471-4270 / 7784
EMAIL: deq076@deq.state.ne.us / deq244@mail.deq.st.ne.us
WEB SITE: http://www.deq.state.ne.us/GroundW/nsf/TOC

NEVADA

Jon Palm
State Health Division
Bureau of Health Protection Services
1179 Fairview Drive, Suite 201
Carson City, NV 89701-5405
PHONE: 775-687-4750 ext. 229
FAX: 775-687-5197

NEW HAMPSHIRE

Sarah Pillsbury
New Hampshire Department of Environmental Services
Water Supply Engineering Bureau
6 Hazen Drive
P.O. Box 95
Concord, NH 03302
PHONE: 603-271-1168
FAX: 603-271-2181
EMAIL: s_pillsbury@des.state.nh.us
WEB SITE: http://www.state.nh.us/des

NEW JERSEY

Sandy Kreitzman
New Jersey Department of Environmental Protection
Bureau of Safe Drinking Water, CM426
East State Street
Trenton, NJ 08625-0426
PHONE: 609-292-5550
EMAIL: skreitzman@dep.state.nj.us
WEB SITE: http://www.state.nj.us/dep/dsr/swap.html

NEW MEXICO

Darren Padilla
Drinking Water Bureau
New Mexico Environment Department
P.O. Box 26110
Santa Fe, NM 87501
PHONE: 505-827-7536
EMAIL: darren_padilla@nmenv.state.nm.us

NEW YORK

Claudine Jones Rafferty
New York State Department of Health
2 University Place, Room 410
Albany, NY 12203
PHONE: 518-458-6743
EMAIL: cfj02@health.state.ny.us
WEB SITE: http://www.health.state.ny.us/nysdoh/water/swap.htm

NORTH CAROLINA

Robert Midgette
Public Water Supply System
North Carolina Department of Environmental, Health, and Natural Resources
P.O. Box 29536
Raleigh, NC 27626-0536
PHONE: 919-733-2321
EMAIL: robert_midgette@mail.enr.state.nc.us
WEB SITE: http://www.deh.enr.state.nc.us/pws/index.htm

NORTH DAKOTA

Dave Glatt
Ground Water Protection Program
Division of Water Quality
1200 Missouri Avenue
Bismarck, ND 58504
PHONE: 701-328-5217
FAX: 701-328-5200
EMAIL: dglatt@state.nd.us
WEB SITE: http://www.health.state.nd.us/ndhd/environ/wq/gw/gwindex.htm

OHIO

Mike Baker
Division of Drinking and Ground Waters
Ohio Environmental Protection Agency
P.O. Box 1049
Columbus, OH 43216-1049
PHONE: 614-644-2752
FAX: 614-644-2909
EMAIL: mike.baker@epa.state.oh.us
WEB SITE: http://www.epa.ohio.gov/ddagw/pdu/swap.html

OKLAHOMA

Mike Houts / Mike Harrell
Water Quality Division
Oklahoma Department of Environmental Quality
1000 NE 10th Street
Oklahoma City, OK 73117-1212
PHONE: 405-702-8100
EMAIL: michael.houts@OKLAOSF.state.ok.us / mike.harrell@OKLAOSF.state.ok.us

OREGON

Dennis Nelson
Oregon Department of Human Services
Drinking Water Program
442 A Street
Springfield, OR 97477
PHONE: 541-726-2587
FAX: 541-682-7499
EMAIL: dennis.o.nelson@state.or.us
WEB SITE: http://www.ohd.hr.state.or.us/cehs/dwp/swp.htm

Sheree Stewart
Drinking Water Protection Program
Oregon Department of Environmental Quality
811 SW 6th Avenue
Portland, OR 97204-1390
PHONE: 503-229-5413
FAX: 503-229-6037
EMAIL: sheree.stewart@state.or.us

PENNSYLVANIA

Joseph Lee
Division of Water Supplies, 11th Floor
Pennsylvania Department of Environmental Resources
400 Market Street, Box 8467
Harrisburg, PA 17105-8467
PHONE: 717-772-4018
EMAIL: lee.joseph@a1.dep.state.pa.us
WEB SITE: http://www.dep.state.pa.us/dep/deputate/watermgt/wsm/WSM_DWM/SrceProt/TACSWPSM.htm

RHODE ISLAND

Clay Commons
Rhode Island Department of Health
Office of Drinking Water Quality
3 Capital Hill
Providence, RI 02908-5097
PHONE: 401-222-6867 ext. 2237
FAX: 401-222-6953
EMAIL: clayc@doh.state.ri.us
WEB SITE: http://www.health.state.ri.us/environment/swaphome.htm

SOUTH CAROLINA

David Baize, Director
Bureau of Water
South Carolina Department of Health and Environmental Control
2600 Bull Street
Columbia, SC 29201-1708
PHONE: 803-734-5323
EMAIL: baizedg@columb32.dhec.state.sc.us
WEB SITE: http://www.state.sc.us/dhec/srcewtr.htm

SOUTH DAKOTA

Anita Yan / Tricia Sebes
South Dakota DENR
Joe Foss Building
523 East Capitol
Pierre, SD 57501-3181
PHONE: 605-773-3296
FAX: 605-773-6035
EMAIL: anitay@denr.state.sd.us / tricias@denr.state.sd.us
WEB SITE: http://www.state.sd.us/denr/DES/Ground/Sourcewater/sourcewater.htm

TENNESSEE

Tom Moss
Ground Water Management Section
Division of Water Supply
Department of Environment and Conservation
401 Church Street
Nashville, TN 37243-1549
PHONE: 615-532-0170
EMAIL: tmoss@mail.state.tn.us
WEB SITE: http://www.state.tn.us/environment/dws/index.html

TEXAS

Brad Cross
Public Drinking Water Section (MC-155)
Texas Natural Resource Conservation Commission
P.O. Box 13087
Austin, TX 78711-3087
PHONE: 512-239-6020
FAX: 512-239-6050
EMAIL: bcross@tnrcc.state.tx.us
WEB SITE: http://www.tnrcc.state.tx.us/water/wu/swap

UTAH

Sumner Newman / Dan Hall
Utah Department of Environmental Quality
Division of Drinking Water
P.O. Box 144830
150 North 1950 West
Salt Lake City, UT 84114-4830
PHONE: 801-536-4195 / 4206
FAX: 801-536-4211
EMAIL: snewman@deq.state.ut.us / dhall@deq.state.ut.us

VERMONT

Elizabeth Hunt
Water Supply Division
Department of Environmental Conservation
103 South Main Street
Waterbury, VT 05671
PHONE: 802-241-3409
FAX: 802-241-3284
EMAIL: elizh@dec.anr.state.vt.us
WEB SITE: http://www.anr.state.vt.us

VIRGINIA

Gerald Peaks
Office of Water Programs
1500 East Main Street, Room 109
Richmond, VA 23219
PHONE: 804-371-2882
EMAIL: gpeaks@vdh.state.va.us

WASHINGTON

David Jennings
Division of Drinking Water
Department of Health
P.O. Box 47822
Olympia, WA 98504-7822
PHONE: 360-586-9041
FAX: 360-586-5529
EMAIL: dgj0303@hub.doh.wa.gov

WEST VIRGINIA

Bill Toomey
West Virginia Department of Health
Environmental Engineering Division
815 Quarrier Street, Suite 418
Charleston, WV 25301
PHONE: 304-558-2981
FAX: 304-558-0691
EMAIL: wtoomey@wvdhhr.org

WISCONSIN

Jeff Helmuth
Wisconsin Department of Natural Resources
Bureau of Drinking Water and Groundwater
P.O. Box 7921
Madison, WI 53707-7921
PHONE: 608-266-5234
FAX: 608-267-7650
EMAIL: helmuj@dnr.state.wi.us
WEB SITE: http://www.dnr.state.wi.us/org/water/dwg/gw/SWP.HTM

WYOMING

Kevin Frederick / Beth Pratt / Maggie Davison
Wyoming Department of Environmental Quality
Water Quality Division
Herschler Building
122 West 25th Street
Cheyenne, WY 82002
PHONE: 307-777-5985 / 7079 / 7092
FAX: 307-777-5973
EMAIL: kfrede@missc.state.wy.us / bpratt@missc.state.wy.us / mdavis@missc.state.wy.us

DISTRICT OF COLUMBIA

Sharon Gonder
DC Department of Health
Water Quality Division
2100 Martin Luther King Drive, Suite 200
Washington, DC 20020
PHONE: 202-645-6601 ext. 3087
FAX: 202-645-5622
EMAIL: sgonder@mail.environ.state.dc.us

PUERTO RICO

Olga I. Rivera
Puerto Rico Department of Health
Public Water Supervision Program
P.O. Box 70184
Edificio A. Centro Medico
San Juan, PR 00909

U.S. VIRGIN ISLANDS

Austin Moorehead
Virgin Islands DPNR/DEP
Water Gut Homes 1118
Christiansted, St. Croix 00820-5065
PHONE: 340-773-0565

Notes

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COMPRENDRE LA LOI

Guide d'interprétation du Décret de désignation du

secteur protégé des bassins hydrographiques du Nouveau-Brunswick

New Nouveau Brunswick
Ministère de l'Environnement et des Gouvernements locaux

COMPRENDRE LA LOI : GUIDE D'INTERPRÉTATION DU *DÉCRET DE DÉSIGNATION DU SECTEUR PROTÉGÉ DES BASSINS HYDROGRAPHIQUES* DU NOUVEAU-BRUNSWICK

TABLE DES MATIÈRES

Déni de responsabilité

Le présent document se veut un guide général seulement et n'est pas un texte juridique.
En cas de conflit apparent entre le guide et le Décret, à noter que le Décret a préséance.

Introduction

Qui devrait lire ce guide?

Le présent guide d'interprétation contient de l'information importante pour tous les résidents et propriétaires d'entreprises situés à l'intérieur des bassins hydrographiques qui approvisionnent les municipalités en eau potable, ainsi que pour les gens qui exploitent les systèmes d'approvisionnement municipal en eau. Il peut également intéresser d'autres Néo-Brunswickois qui cherchent de l'information générale sur la protection des bassins hydrographiques. Essentiellement, le Décret de désignation gère ou contrôle les activités d'utilisation des terres et de l'eau dans les bassins hydrographiques. Si vous habitez ou travaillez dans un bassin hydrographique servant de source d'approvisionnement municipal en eau potable, et que vous participez à une des activités indiquées ci-dessous, vous devriez lire ce guide. Les activités visées sont :

- l'agriculture,
- l'exploitation forestière,
- la construction de chemins,
- l'aménagement commercial et industriel,
- l'extraction minière,
- les loisirs,
- l'aquaculture,
- l'aménagement résidentiel.

Pourquoi ce guide?

Ce guide vous initie au ***Décret de désignation du secteur protégé des bassins hydrographiques***. Ce guide vous aidera à comprendre et à respecter le Décret. Il fournit de l'information de base sur les bassins hydrographiques désignés et ensuite aborde le Décret, article par article, expliquant brièvement en langage simple, ce qui est visé par chaque article.

Il faut se rappeler que le guide n'est pas une interprétation juridique. C'est plutôt un survol détaillé du Décret qui explique son importance pour vous et votre entreprise. Le Décret est la référence juridique qui explique comment vous pouvez respecter ses exigences et sauvegarder l'approvisionnement municipal en eau. En cas de conflit entre le guide et le Décret, ce dernier a préséance.

À noter également que des modifications peuvent être apportées à l'occasion au Décret. Pour vous assurer que l'information que vous possédez est exacte et à jour, vous pouvez communiquer avec la Direction de la planification durable du ministère de l'Environnement et des Gouvernements locaux (annexe B).

Bassins hydrographiques du Nouveau-Brunswick

L'eau provient habituellement d'une de deux principales sources : eau souterraine ou bassin hydrographique. Un bassin hydrographique est une zone de terrain qui draine l'eau de surface d'un réseau de cours d'eau tels que des ruisseaux, des rivières ou des lacs. La superficie de la province englobe plusieurs douzaine de bassins hydrographiques attenants qui ont évolué lentement au cours de millions d'années.

Les scientifiques ont désigné au Nouveau-Brunswick 30 différents bassins hydrographiques qui fournissent de l'eau potable aux municipalités. Ces **bassins hydrographiques désignés** couvrent seulement 4 % de la superficie totale de la province, mais desservent 21 localités et plus de 300 000 résidents.

Les bassins hydrographiques sont situés dans des régions peuplées, ce qui les rend très vulnérables à la contamination causée par les activités humaines. Le bassin hydrographique contaminé peut se traduire par de l'eau non potable pour des milliers de personnes et peut ruiner l'habitat d'innombrables organismes vivants.

Comment les bassins hydrographiques peuvent-ils être contaminés?

La contamination peut être causée par des substances chimiques et d'autres substances toxiques que nous produisons, utilisons, jetons ou déversons, entreposons de façon non convenable. Ces substances peuvent pénétrer dans un cours d'eau directement à partir d'une **source ponctuelle** comme une fosse septique ou un baril de pétrole, ou indirectement à partir des **écoulements de surface** ou de **l'infiltration souterraine**. Les pesticides, les eaux usées, les produits pétroliers, les engrais et les lubrifiants, voilà autant d'exemples de polluants qui peuvent aboutir dans un cours d'eau.

Des dommages physiques peuvent être causés aux cours d'eau par des usages des terres comportant l'utilisation de matériel lourd ou de mauvaises techniques de gestion qui provoquent l'érosion des sédiments et le compactage du sol. L'érosion et le compactage du sol peuvent permettre aux sédiments et aux substances nutritives de pénétrer dans un cours d'eau où ils peuvent ruiner l'habitat du poisson, favoriser la croissance d'algues et modifier la forme et le débit du cours d'eau.

Pourquoi ne pas traiter l'eau seulement après qu'elle est polluée?

Il n'est tout simplement pas rentable ni préférable pour l'environnement d'attendre de traiter l'eau *après* qu'elle est devenue polluée. La construction et l'exploitation d'une installation de l'eau coûtent cher, surtout pour les petites collectivités. De plus, le traitement de l'eau

municipale ne garantit pas toujours une eau sécuritaire. Parfois, même le système le plus efficace ne peut pas contrôler ou enlever certains virus ou polluants chimiques, et les défaillances mécaniques peuvent perturber les approvisionnements en eau.

L'expérience a démontré qu'il est beaucoup plus rentable de bien protéger un bassin hydrographique, que d'attendre et d'être obligé de le nettoyer après qu'il est devenu pollué ou de trouver une autre source d'approvisionnement en eau. Le gouvernement du Nouveau-Brunswick a donc élaboré un *Décret de désignation du secteur protégé des bassins hydrographiques* qui constitue une approche proactive en matière de protection des bassins hydrographiques. Le Décret est un des éléments du Programme de protection des bassins hydrographiques à long terme du gouvernement, qui est résumé à l'annexe C.

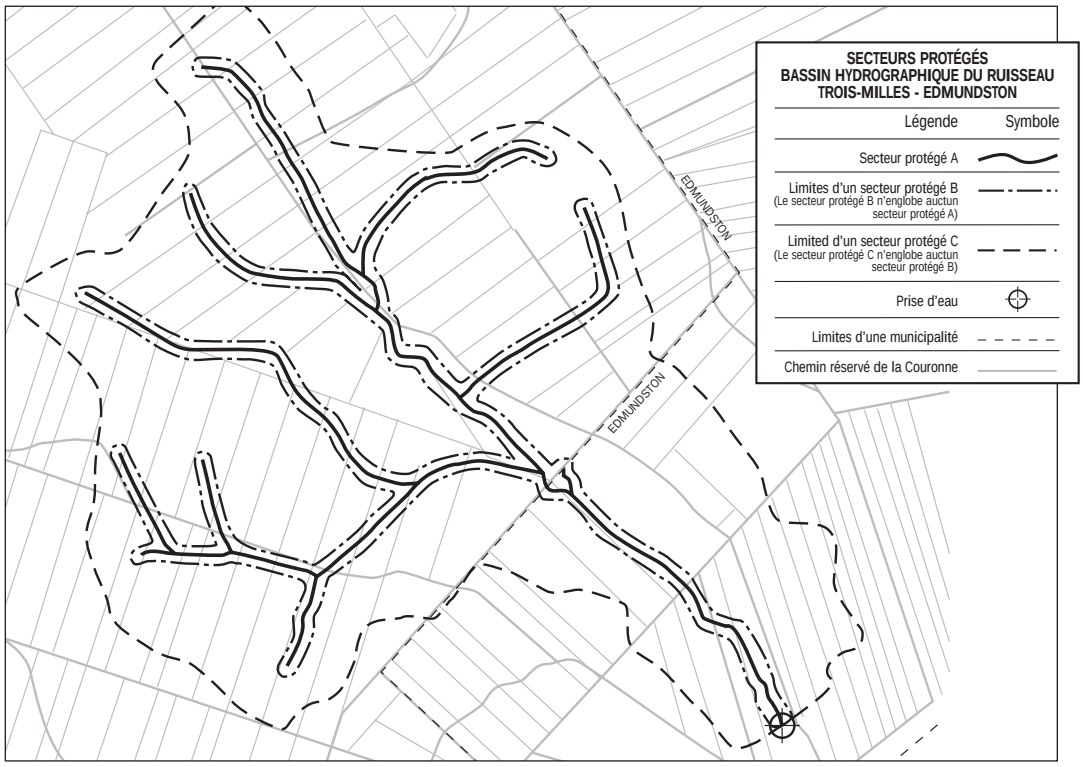
Avant d'examiner le *Décret de désignation du secteur protégé des bassins hydrographiques* en détail, nous repasserons brièvement les principes des bassins hydrographiques désignés et des zones de retrait, qui sont des éléments essentiels à la compréhension du Décret proprement dit.

Bassins hydrographiques désignés et zones de retrait

La superficie de terre immédiatement adjacente aux rives d'un cours d'eau constitue une zone tampon naturelle qui, si elle est laissée intacte, protège l'eau contre la contamination. Les racines des arbres et d'autres types de végétation protègent le sol contre l'érosion et le sol et la végétation contribuent à absorber ou à filtrer autrement les éléments nutritifs et les substances toxiques. Le surenrichissement causé par des quantités excessives d'éléments nutritifs entre autres favorise la croissance d'algues, ce qui réduit considérablement la quantité d'oxygène et augmente la matière organique dans l'eau.

Chacun des 30 bassins hydrographiques désignés du Nouveau-Brunswick a une zone tampon désignée appelée une **zone de retrait** qui englobe toute la superficie à l'intérieur des 75 mètres des rives de la plupart des cours d'eau du bassin hydrographique. Cette zone constitue une zone tampon entre les cours d'eau et les activités pouvant être nocives. Elle contribue à prévenir la pénétration des sédiments et d'autres polluants dans les rivières, les ruisseaux et les lacs dans le bassin hydrographique.

Pourtant, les zones de retrait n'ont qu'une capacité limitée de protéger les cours d'eau adjacents contre la pollution. Les quantités excessives de substances toxiques ou l'érosion qui proviennent d'au-delà de la zone tampon peuvent surpasser sa capacité d'absorption. Cette situation peut provoquer la pollution de l'eau. Les activités qui ont lieu au-delà de la zone de retrait mais à l'intérieur du bassin hydrographique peuvent donc contaminer les cours d'eau, dans certaines conditions.



Le *Décret de désignation du secteur protégé des bassins hydrographiques*

Comment le Décret est-il conçu?

Chaque secteur désigné comprend trois zones distinctes :

- la zone de retrait de 75 m,
- le reste de la zone de drainage du bassin hydrographique, qui est la zone de terrain située à *l'extérieur* de la zone de retrait mais à *l'intérieur* des limites du bassin hydrographique,
- le cours d'eau proprement dit.

Le Décret désigne ces trois zones comme le secteur protégé A, le secteur protégé B et le secteur protégé C. La phase I du Programme de protection des bassins hydrographiques mise en œuvre en 1990 a établi des normes relatives aux activités d'utilisation des terres à l'intérieur de la zone de retrait. La phase II, qui est maintenant en cours de mise en œuvre moyennant le *Décret de désignation du secteur protégé des bassins hydrographiques*, comprend l'établissement de normes pour les activités d'utilisation des terres et de l'eau dans le reste de la zone de drainage du bassin hydrographique et dans les cours d'eau proprement dits.

Le Décret interdit certaines activités partout à l'intérieur du bassin hydrographique de la source d'approvisionnement en eau potable. D'autres activités sont permises dans le reste de la zone de drainage, mais non dans la zone de retrait. D'autres activités peuvent être permises à l'intérieur de la zone de retrait uniquement à certaines conditions précises. Bien entendu, toutes les activités permises à l'intérieur de la zone de retrait le sont également dans le reste de la zone de drainage.

Décret de désignation du secteur protégé des bassins hydrographiques en détail

Les pages suivantes du guide donnent un compte rendu détaillé du Décret et expliquent de façon succincte et en langage simple ce qui est prévu par chaque article. À des fins de précision, l'information est répartie entre les activités d'utilisation des terres ou d'utilisation de l'eau comme l'exploitation forestière, l'agriculture, l'extraction minière, etc.

Il importe de comprendre que le Décret vise à prévenir la pollution de l'eau avant qu'elle ne survienne, et à protéger les bassins hydrographiques désignés du Nouveau-Brunswick contre la pollution. En plus des exigences relatives à l'utilisation des terres et de l'eau prévues dans le Décret, le ministère de l'Environnement et des Gouvernements locaux encourage fortement les agriculteurs et les travailleurs forestiers de la province à adopter des méthodes de gestion optimale. Ces techniques pratiques ont été adoptées dans une bonne partie du Canada. Elles augmentent l'efficacité et réduisent les coûts d'exploitation tout en prévenant la contamination de l'eau. Vous pouvez vous procurer des vidéos et d'autre matériel éducatif sur les méthodes de gestion optimale au bureau le plus près du ministère de l'Environnement et des Gouvernements locaux.

Encore une fois, n'oubliez pas que ce guide n'est pas un document juridique. Le Décret proprement dit est la référence juridique qui explique comment vous pouvez respecter les exigences du Décret. Il faudra consulter le Décret ainsi que ce guide pour un compte rendu plus précis des activités qui sont permises dans les bassins hydrographiques désignés.

Article 1
Introduction

L'article 1 définit les termes les plus courants utilisés dans le Décret.

Article 2
Interdiction générale

Le *Décret de désignation du secteur protégé des bassins hydrographiques* précise au tout début que toutes les activités, toutes les choses ou tous les usages qui ne sont pas décrits dans le Décret sont interdits dans un secteur du bassin hydrographique désigné. Autrement dit, si une activité ou une chose ou un usage n'est pas précisé dans le Décret, cette activité, cette chose ou cet usage n'est pas permis dans les bassins hydrographiques désignés.

Article 3
Installations d'approvisionnement public en eau

Une personne ou un groupe peut entretenir, développer ou agrandir une installation d'approvisionnement public en eau dans un bassin hydrographique désigné pourvu qu'il obtienne et maintienne toutes les autorisations requises en vertu des lois applicables expliquées dans ce Décret ou autre législation gouvernementale. Également, ce groupe ou cette personne doit s'assurer de protéger et de maintenir la qualité de l'eau dans le bassin hydrographique.

Article 4
Conditions générales

Les activités permises en vertu de ce Décret sont autorisées uniquement à la condition qu'elles n'émettent pas de polluants dans les cours d'eau, et qu'elles soient conformes à toutes les lois fédérales, provinciales et municipales applicables.

Depuis son adoption en 1989, la Loi sur l'assainissement de l'eau a été modifiée plusieurs fois. Si un autre décret ou une autre partie de la Loi sur l'assainissement de l'eau permet une activité ou une chose qui est interdite dans le *Décret de désignation du secteur protégé des bassins hydrographiques*, le *Décret de désignation du secteur*

protégé des bassins hydrographiques a préséance. If a conflict exists between the Watershed Protected Area Designation Order and other Provincial legislation, the more stringent provisions, including any conditions, would prevail.

Article 5
Activités, choses et usages permis dans les cours d'eau (secteur protégé A)

Cet article indique les activités qui sont permises dans le cours d'eau; c'est-à-dire dans les lacs, les rivières, les ruisseaux et autres cours d'eau de bassins hydrographiques désignés.

Article 6
Activités permises dans la zone de retrait (secteur protégé B)

Cet article indique les diverses activités qui sont permises dans la zone de retrait de 75 m ou dans la zone tampon située immédiatement adjacente au cours d'eau dans un bassin hydrographique.

Article 7
Activités permises dans le reste de la zone de drainage (secteur protégé C)

Cet article du Décret décrit les autres activités qui sont permises dans le secteur protégé C. **Comme il a déjà été mentionné, toutes les activités permises dans une zone de retrait (secteur protégé B) le sont également dans le reste de la zone de drainage d'un bassin hydrographique désigné ou dans le secteur protégé C.**

Le tableau suivant explique en détail les activités qui sont permises dans chacun des secteurs protégés.

Activités permises dans les zones A, B et C

	Zone(s)		
	Activités permises dans les cours d'eau (Secteur protégé A)	Activités permises dans la zone de retrait (Secteur protégé B)	Activités permises dans le reste du bassin hydrographique (Secteur protégé C)
Utilisation d'embarcations non motorisées	Les embarcations non motorisées peuvent être utilisées pour la navigation et la pêche dans tous les bassins hydrographiques désignés.		
Embarcations motorisées et natation Généralement non permises dans les bassins hydrographiques désignés, à l'exception des activités suivantes :	Vous pouvez utiliser une embarcation motorisée et vous baigner dans les cours d'eau dans • le bassin hydrographique Loch Lomond à l'extérieur des limites de la ville de Saint-Jean; • le bassin hydrographique du lac Chamcook, pourvu que vous restiez à plus de 500 m de la prise d'eau de l'installation d'approvisionne-ment public en eau; • le bassin hydrographique Musquash; • le lac Moores Mills dans le bassin hydrographique du ruisseau Dennis. Les embarcations motorisées dans ces secteurs des bassins hydrographiques doivent répondre aux conditions suivantes : • Aucun moteur à deux temps n'est permis (c.-à-d. moteurs lubrifiés avec un mélange de carburant). Également, le plus gros moteur permis pour une		

Activités permises dans les zones A, B et C

	Zone(s)		
	Activités permises dans les cours d'eau (Secteur protégé A)	**Activités permises dans la zone de retrait (Secteur protégé B)**	**Activités permises dans le reste du bassin hydrographique (Secteur protégé C)**
	embarcation est de 10 chevaux-vapeurs afin de prévenir l'érosion de la rive causée par le mouvement accessible des vagues. • Tous les réservoirs à carburant doivent être attachés fermement à l'embarcation et être fermés hermétiquement de sorte à empêcher une fuite si l'embarcation chavire. Aucune embarcation ne doit transporter une quantité totale de plus de 25 litres de carburant dans un ou des réservoirs qui ne sont pas intégrés à l'embarcation. Aucune embarcation ayant des toilettes à bord ne doit être conduite dans ce secteur.		
Véhicules motorisés		Vous pouvez conduire un véhicule à moteur sur les routes provinciales actuelles qui traversent une zone de retrait. Vous pouvez conduire des véhicules de loisirs motorisés comme les véhicules tout-terrain, mais vous devez utiliser les passages de cours d'eau approuvés pour traverser un ruisseau ou une rivière.	
Activités récréatives		Vous pouvez pêcher, chasser, piéger (pourvu que vous ayez la licence nécessaire), faire du canot, étudier la faune, faire du ski de fond, de la raquette et vous adonner à des activités semblables sur une base récréative.	
Récolte des plantes sauvages		Vous pouvez récolter les plantes sauvages comme les baies à l'aide de dispositifs mécaniques non motorisés. Vous pouvez exploiter une érablière à moins de 30 m d'un cours d'eau, pourvu que vous n'utilisiez aucun matériel mécanique et que vous ne transformiez pas la sève dans le secteur.	
Activités de protection des cours d'eau et de mesures d'urgence		Vous pouvez vous adonner à des activités qui protégeront la rive des cours d'eau à condition que vous obteniez les permis nécessaires et que vous respectiez les lignes	

Activités permises dans les zones A, B et C

	Zone(s)		
	Activités permises dans les cours d'eau (Secteur protégé A)	**Activités permises dans la zone de retrait (Secteur protégé B)**	**Activités permises dans le reste du bassin hydrographique (Secteur protégé C)**
		directrices énoncées dans le Règlement sur la modification des cours d'eau. Toute activité liée aux opérations d'urgence et à l'application de la loi pour la santé et la sécurité du public, ou pour la protection des ressources naturelles, est permise.	
Propriétés résidentielles		Vous pouvez maintenir ou améliorer des systèmes de fosses septiques actuels et effectuer des travaux d'entretien routiniers sur votre résidence. Vous pouvez reconstruire, rénover ou entretenir des habitations unifamiliales et multifamiliales existantes, pourvu que • La structure finie ne soit pas supérieure à 2 000 pieds carrés ou que la surface de plancher utilisable ne soit pas supérieure à 1,5 fois la superficie de l'ancienne structure, selon la surface la moins grande. • Si votre habitation originale est endommagée ou détruite, l'habitation de remplacement ne soit pas plus près du cours d'eau que l'habitation originale. • La rénovation ou la reconstruction n'augmente pas le nombre d'unités familiales. • Vous soumettiez votre plan de reconstruction, de rénovation ou d'agrandissement au ministre de l'Environnement et des Gouvernements locaux avant le début des travaux de rénovation. • Vous preniez les mesures qui s'imposent pour prévenir l'évacuation de sédiments dans les cours d'eau adjacents.	
Aménagement paysager résidentiel		Les activités d'aménagement paysager sont permises pourvu que l'aménagement ne soit pas à moins de 5 m des cours d'eau, et que tous les arbres vivants dans un rayon de 15 m du cours d'eau soient laissés	

Activités permises dans les zones A, B et C

	Zone(s)		
	Activités permises dans les cours d'eau (Secteur protégé A)	**Activités permises dans la zone de retrait (Secteur protégé B)**	**Activités permises dans le reste du bassin hydrographique (Secteur protégé C)**
		debout. Les arbres morts ou les chablis toutefois peuvent être enlevés à moins de 15 m des cours d'eau.	
Foresterie Nota : La coupe de jardinage est effectuée pour entretenir un peuplement d'arbres bien réparti et d'autres végétations sur votre propriété, et pourvu qu'on ne laisse pas d'ouverture dans le tapis forestier d'une superficie supérieure à 300 mètres carrés. Les arbres ne devraient pas être coupés à moins que leur diamètre soit de 10 cm ou plus à la hauteur d'homme (1,36 m).		À un kilomètre ou moins en amont de la prise d'une installation d'approvisionnement public en eau, vous pouvez planter des arbres à une distance d'entre 30 m et 75 m des rives d'un cours d'eau. Effectuer une coupe de jardinage à l'aide de moyens mécaniques ou non mécaniques d'une distance d'entre 30 et 75 m des rives d'un cours d'eau pourvu que : • pas plus de 30 % des troncs et pas plus de 30 % du volume des arbres sur une parcelle quelconque située à l'intérieur de la zone de retrait ne soient coupés; • la coupe de jardinage sur la parcelle ne soit pas faite plus d'une fois tous les cinq ans; • il faut respecter le calendrier établi pour la coupe de jardinage: Au sud de Bath, comté de Carleton – du 1er janvier au 31 mars. Au nord de Bath, comté de Carleton – du 1er novembre au 31 mars. *À plus d'un kilomètre en amont d'une installation d'approvisionnement public en eau, vous pouvez* planter des arbres à une distance d'entre 15 et 75 m des cours d'eau. Faire une coupe de jardinage à l'aide de moyens mécaniques ou non mécaniques à une distance d'entre 15 m et 75 m des rives du cours d'eau pourvu que • pas plus de 30 % des troncs et pas plus de 30 % du volume des arbres sur une parcelle quelconque située dans la zone de retrait d'un des biens-fonds ne soient coupés pendant	Vous pouvez entreprendre des activités forestières pourvu que : • les coupes à blanc ne dépassent pas 25 hectares. • Vous laissiez une zone tampon non récoltée d'au moins 100 mètres de largeur entre les zones coupées à blanc (ou de 50 m lorsque la coupe à blanc se trouve près des lignes foncières); cette bande peut faire l'objet d'une coupe de jardinage, mais ne peut pas être coupée à blanc pendant au moins 10 ans après la première coupe à blanc OU jusqu'à ce que la régénération dans la zone coupée à blanc atteigne une hauteur moyenne de 2 m, selon l'événement qui se produit le premier. • Vous ne coupiez à blanc pas plus de 25 % du bien sur les terres d'une superficie supérieure à 10 hectares, et que vous ne fassiez pas de coupe à blanc sur la même partie pendant au moins 10 ans OU jusqu'à ce que la régénération atteigne une hauteur moyenne de 2 m, selon l'événement qui se produit le premier. • Le niveau de solides en suspension dans les eaux d'écoulement ou dans les eaux de drainage se déversant dans les cours d'eau des aires de débarquement ou des cours à bois, ou résultant des activités de scarifiage ne dépasse pas 25 mg/1 au-dessus des concentrations de fond. • Les activités de bulldozer ne doivent pas mettre à nu du sol minéral sur plus de 5 % de toute parcelle, y compris tous les chemins et toutes les aires de débarquement.

Activités permises dans les zones A, B et C

	Zone(s)		
	Activités permises dans les cours d'eau (Secteur protégé A)	**Activités permises dans la zone de retrait (Secteur protégé B)**	**Activités permises dans le reste du bassin hydrographique (Secteur protégé C)**
		une période de cinq ans, OU que le volume des arbres enlevés soit conforme à un plan d'aménagement forestier préparé par un forestier professionnel agréé. • Vous respectiez les calendriers suivants pour la coupe de jardinage. Au sud de Bath, comté de Carleton – du 1er janvier au 31 mars. Au nord de Bath, comté de Carleton – du 1er novembre au 31 mars.	
Agriculture		*Sur les terres agricoles situées à un kilomètre ou moins en amont d'une prise d'une installation d'approvisionnement public en eau*, vous pouvez continuer d'exercer les activités agricoles courantes à une distance d'entre 30 m et 75 m des cours d'eau pourvu que : • le labourage soit effectué en travers la pente et ne soit pas effectué sur des pentes supérieures à 20 %; • aucun ruissellement de surface venant d'un champ ne s'écoule directement dans un cours d'eau; • vous épandiez seulement de l'engrais inorganique ou utilisiez uniquement de l'engrais vert et n'appliquiez pas d'engrais sur votre terre dans cette zone; • les champs utilisés pour le pâturage du bétail comprennent une clôture convenable construite de façon à empêcher le bétail d'avoir accès au secteur dans les 30 m d'un cours d'eau. *Sur les terres agricoles situées à plus d'un km en amont d'une prise d'une installation d'approvisionnement public en eau*, vous pouvez couper et enlever le foin à cinq mètres ou moins d'un cours d'eau. Vous pouvez entreprendre des activités agricoles à une distance d'entre 15 m et 75 m des rives d'un cours d'eau	Vous pouvez entreprendre des activités agricoles pourvu que : • vous n'appliquiez, n'entreposiez ou n'utilisiez pas d'engrais dans le secteur; • le niveau de solides en suspension dans les eaux d'écoulement ou dans les eaux de drainage s'écoulant des champs agricoles dans le cours d'eau ne dépasse pas 25 mg/l au-dessus des niveaux de fond; • You do not convert a field planted with a non-row crop such as alfalfa to a row crop such as potatoes; • toutes cultures en rangées existantes comprennent une bande couverte d'herbe d'au moins cinq mètres de largeur le long de la pente du champ, et près d'un cours d'eau ou d'un fossé agricole; • toutes les terres agricoles soient plantées avec une culture ou autre végétation qui empêche l'érosion; • pas plus de 5 % de chaque parcelle de terrain soit coupée à blanc pour l'agriculture chaque année. Toutefois, deux hectares supplémentaires de terrain dans le secteur protégé C peuvent être coupés à blanc à des fins agricoles pour chaque hectare de terrain à l'intérieur du secteur protégé B qui est stabilisé et qui a été soustrait à la production agricole l'année précédente.

Activités permises dans les zones A, B et C

	Zone(s)		
	Activités permises dans les cours d'eau (Secteur protégé A)	**Activités permises dans la zone de retrait (Secteur protégé B)**	**Activités permises dans le reste du bassin hydrographique (Secteur protégé C)**
		pourvu que : • le labourage soit effectué en travers la pente et ne soit pas effectué sur des pentes supérieures à 20 %; • aucun ruissellement de surface venant d'un champ ne s'écoule directement dans un cours d'eau; • vous épandiez seulement de l'engrais inorganique ou utilisiez uniquement de l'engrais vert et n'appliquiez pas d'engrais sur votre terre dans cette zone; • les champs utilisés pour le pâturage du bétail comprennent une clôture convenable construite de façon à empêcher le bétail d'avoir accès au secteur dans les 15 m d'un cours d'eau.	
Pesticides		À un kilomètre ou moins en amont de la prise d'une installation d'approvisionnement public en eau à une distance, des pesticides peuvent être appliqués d'entre 30 et 75 m des rives d'un cours d'eau pourvu que les personnes qui appliquent les pesticides détiennent le certificat approprié en vertu de la *Loi sur le contrôle des pesticides*. À plus d'un km en amont de la prise de l'installation d'approvisionnement public en eau, des pesticides peuvent être appliqués à une distance d'entre 15 et 75 m des rives d'un cours d'eau, pourvu que les personnes qui appliquent les pesticides détiennent le certificat approprié exigé en vertu de la *Loi sur le contrôle des pesticides*.	
Construction de routes		Vous pouvez construire des chemins aux passages de cours d'eau approuvés par le ministre de l'Environnement et des Gouvernements locaux en vertu du Règlement sur la modification des cours d'eau. Toute construction de chemin doit être conforme aux critères	La construction de routes est permise dans le reste de la zone de drainage du bassin hydrographique pourvu que : • des fossés de dérivation adéquats ou des barres de dérivation de l'eau adéquates soient construits pour empêcher l'évacuation directe des sédiments dans les cours

Activités permises dans les zones A, B et C

	Zone(s)		
	Activités permises dans les cours d'eau (Secteur protégé A)	**Activités permises dans la zone de retrait (Secteur protégé B)**	**Activités permises dans le reste du bassin hydrographique (Secteur protégé C)**
		établis dans le *Décret de désignation du secteur protégé des bassins hydrographiques*. Ces critères décrivent comment construire les fossés de dérivation, les bassins de sédiments, les stabilisateurs de perré, les largeurs de l'accotement, les assiettes, les barrières d'eau, les emprunts, les fossés et les ponceaux. Les critères visent à limiter l'érosion et la perturbation du sol et à empêcher les sédiments de pénétrer dans les cours d'eau. Vous pouvez vous procurer le Décret au bureau local le plus près du ministère de l'Environnement et des Gouvernements locaux (annexe B).	d'eau; • des pièges de sédiments adéquats soient construits sur le chantier de construction exposé, y compris des pièges placés dans les fossés, jusqu'à ce que toute la zone soit nivelée et stabilisée; • toutes les assiettes de route sauf les chemins agricoles et forestiers soient recouvertes d'asphalte, de pierres concassées bituminées ou d'agrégats; • tous les chemins agricoles et de lots boisés soient conçus afin d'éviter la sédimentation d'un cours d'eau pendant la construction et l'utilisation de ces chemins par la suite, et soient construits uniquement là où la pente est inférieure à 15 %; • tous les chemins construits qui deviennent affouillés soient rétablis et stabilisés immédiatement. Pour consulter d'autres lignes directrices sur la construction de routes, voir le Règlement sur la modification des cours d'eau.
Arpentage, extraction et production de minéraux		L'arpentage et l'installation de panneaux sont permis dans la zone de retrait. L'exploration minière à ciel ouvert est permise. L'exploration minière souterraine, l'aménagement et l'extraction sont également permis, pourvu que les activités aient lieu à une profondeur suffisante pour ne pas perturber ou contaminer des cours d'eau.	L'extraction et l'écrasement du sable, du gravier et d'autres matériaux agrégats semblables sont permis, mais ces matériaux doivent être transportés au-delà de la zone du bassin hydrographique pour être transformés davantage jusqu'au lavage et au triage. Les activités minières de métaux de base sont permises pourvu que tous les effluents des activités minières et de la transformation des minéraux soient évacués au-delà du secteur du bassin hydrographique désigné.
Postes de pompage et installations d'énergie électrique		Vous pouvez installer un poste de pompage électrique partout dans la zone de retrait et installer un poste de pompage alimenté au combustible à une distance d'entre 30 m et 75 m d'un cours d'eau dans la zone de retrait pourvu que :	

Activités permises dans les zones A, B et C

	Zone(s)		
	Activités permises dans les cours d'eau (Secteur protégé A)	**Activités permises dans la zone de retrait (Secteur protégé B)**	**Activités permises dans le reste du bassin hydrographique (Secteur protégé C)**
		• ce poste soit muni d'un dispositif de prévention d'écoulement de retour approuvé par l'Association canadienne de normalisation; • les tuyaux de prise d'eau soient situés à au moins 100 m en aval ou à 500 m en amont de la prise d'une installation d'approvisionnement public en eau la plus près et ne perturbent pas le lit ou la ligne de rivage d'un cours d'eau; • le bout des tuyaux de prise d'eau soit muni d'un grillage qui est assez gros pour permettre le débit d'eau sans interruption (voir le Décret pour d'autres détails sur les mesures), et qui n'a pas d'ouverture supérieure à 57 mm carrés; • le taux maximum de retrait d'eau du cours d'eau permette le maintien d'un débit mensuel d'au moins 25 % dans le cours d'eau, dans le lac ou dans la rivière en tout temps. Les sous-stations électriques ou les stations terminales ou les lignes de transport peuvent être construites ou exploitées dans la mesure où elles utilisent des passages de cours d'eau approuvés.	
Stockage de produits pétroliers			Les nouveaux réservoirs de produits pétroliers peuvent être installés, entretenus, utilisés ou enlevés si les activités connexes sont conformes au Règlement sur le stockage et la manutention des produits pétroliers de la *Loi sur l'assainissement de l'environnement*.
Aquaculture		La construction, l'exploitation et l'entretien d'ouvrages de prise d'eau seulement et des ouvrages de transport pour les activités aquacoles sont permis, pourvu que • l'exploitant obtienne les autorisations nécessaires en vertu des lois, des arrêtés et des autres lois concernant les exploitations aquacoles du Nouveau-Brunswick qui s'appliquent. On peut obtenir d'autres détails sur la réglementation aquacole du ministère de l'Environnement et des Gouvernements locaux; • l'exploitant adopte toutes les mesures de précaution possibles pour respecter et sauvegarder la qualité de l'eau.	

Autres questions

Suis-je touché par le Décret de désignation du secteur protégé des bassins hydrographiques?

Maintenant que vous avez lu ce guide, vous voudrez probablement savoir si votre maison ou votre commerce est situé dans un bassin hydrographique désigné – si oui, vous voudrez savoir quels effets cela aura sur vous.

Vous devez d'abord consulter la liste des bassins hydrographiques désignés fournie à l'annexe C. S'il semble que votre propriété peut être située dans un de ces bassins hydrographiques, vous pouvez communiquer avec le bureau le plus près du ministère de l'Environnement et des Gouvernements locaux (annexe B) ou avec le bureau de la Corporation d'information géographique. Le personnel de ces bureaux vous montrera des cartes des secteurs de bassins hydrographiques désignés et vous aidera à situer votre résidence ou votre commerce sur la carte. Il peut également expliquer les ruisseaux ou les cours d'eau sur votre propriété qui peuvent être touchés par le Décret de désignation du secteur protégé des bassins hydrographiques.

Qu'est-ce qui est considéré comme un cours d'eau?

Tous les lacs, rivières et ruisseaux dans un bassin hydrographique désigné sont considérés comme des cours d'eau. (See Glossary for detailed definition.)

Les restrictions concernant la zone de retrait s'appliquent uniquement aux cours d'eau qui sont identifiés de façon précise sur les plans connus comme le registre général des zones de retrait. Vous pouvez examiner ou acheter des copies de ces plans au bureau le plus près du ministère de l'Environnement et des Gouvernements locaux ou au bureau de la Corporation d'information géographique. Ces plans sont également disponibles aux bureaux régionaux du ministère de l'Agriculture, du ministère des Ressources naturelles et de l'Énergie et du ministère de la Santé et du Mieux-être.

Si je ne puis pas respecter le Décret de désignation du secteur protégé des bassins hydrographiques?

Si vous constatez que vous travaillez ou habitez dans un bassin hydrographique désigné, et que vous êtes en cours de développer, de construire, d'exploiter ou d'entretenir une activité ou un usage qui est interdit, contrôlé ou autrement visé par le Décret?

Si vous avez examiné d'autres solutions, emplacements ou activités, et que vous estimez encore ne pas pouvoir respecter les exigences du Décret?

Sans doute que certains développements ou activités existantes à l'intérieur d'un bassin hydrographique désigné ne seront pas conformes au Décret. Votre moyen de recours dans un tel cas est de demander une exemption par écrit à la ministre de l'Environnement et des Gouvernements locaux.

Dès que vous avez rempli et soumis votre formulaire d'exemption, le ministre de l'Environnement et des Gouvernements locaux a trois choix :

- accorder l'exemption avec des conditions précises
- refuser la demande d'exemption
- acquérir la totalité ou une partie du terrain.

Autre information

Pour obtenir des exemplaires du formulaire d'exemption ou d'autre information au sujet du présent guide ou du Décret de désignation du secteur protégé des bassins hydrographiques communiquez avec la :

Direction de la planification durable
Ministère de l'Environnement et des Gouvernements locaux du N.-B.
C.P. 6000
Fredericton (Nouveau-Brunswick)
E3B 5H1

Téléphone : 506 457-4846
Télécopieur : 506 457-7823

ou avec un des bureaux régionaux du ministère : voir l'annexe B.

Vous pouvez consulter le site Web du ministère sur la protection des bassins hydrographiques à : http://www.gnb.ca/elg-egl/0373/0001/0002-f.html.

Nota : On peut acheter des exemplaires de la Loi sur l'assainissement de l'eau et de ses règlements ou communiquer avec
L'Imprimeur de la Reine du Nouveau-Brunswick
C.P. 6000, Bureau 115
Édifice du Centenaire
Fredericton (Nouveau-Brunswick) E3B 5H1
Téléphone : 506 453-2520
Télécopieur : 506 457-7899.

On peut également accéder électroniquement à toutes les Lois du Nouveau-Brunswick en visitant la page d'accueil du ministère de la Justice à
http://www.gnb.ca/justice/index.htm.

Annexes

Annexe A : Glossaire

Aménagement paysager : Désigne la modification des conditions du sol existantes ainsi que la construction de caractéristiques du sol et comprend des ouvrages mineurs mais n'englobe pas les garages, les piscines, les étangs ou autres ouvrages importants.

Bassin hydrographique : Une zone de trait qui draine l'eau de surface d'un réseau de cours d'eau et qui se déverse dans une rivière, un ruisseau, un crique ou autre cours d'eau qui s'écoule.

Bassin hydrographique d'une source d'approvisionnement en eau potable : Un bassin hydrographique utilisé pour assurer de l'eau potable au public pour une ou plusieurs municipalités. Le Nouveau-Brunswick a 30 bassins hydrographiques municipaux.

Cours d'eau : Un ruisseau, un lac, une rivière ou autre cours d'eau. En vertu de la Loi sur l'assainissement de l'eau, cours d'eau désigne la largeur et la longueur totale, y compris le lit, les berges, les bords et la ligne du rivage ou toute autre partie d'une rivière, d'une source, d'un ruisseau, d'un lac, d'un étang, d'un réservoir, d'un canal, d'un fossé ou de tout autre canal à ciel ouvert, naturel ou artificiel, dont la principale fonction est de transiter ou de retenir l'eau, que l'écoulement soit continu ou non.

Décret de désignation de la marge de retrait des cours d'eau : Un décret est pris en vertu de la Loi sur l'assainissement de l'eau qui indique les activités permises dans la marge de retrait de 75 m, ou dans un secteur protégé, qui peuvent avoir lieu le long d'un cours d'eau des bassins hydrographiques.

Engrais vert : Plantes vertes ou ayant atteint la maturité, riches en azote qui sont enfouies pour enrichir le sol.

Évacuation ou contamination d'une source ponctuelle : Rejets polluants évacués directement dans l'environnement, habituellement (mais pas toujours) à travers un tuyau d'évacuation. Comprend des effluents des procédés commerciaux industriels et les déchets humains ramassés.

Gué : Passage d'une rivière dans de l'eau peu profonde sur le lit de la rivière.

Méthode de gestion optimale : Une méthode, une mesure ou une pratique qui une fois appliquée ou utilisée est conforme à une activité saine sur le plan pratique, technique et environnemental. Une méthode de gestion optimale visant spécifiquement à assurer la qualité de l'eau, empêchera, réduira ou corrigera la pollution de l'eau.

Passage de cours d'eau approuvé : Désigne un passage de cours d'eau qui a été approuvé par le ministre de l'Environnement et des Gouvernements locaux en vertu du Règlement sur la modification des cours d'eau – Loi sur l'assainissement de l'eau.

Scarifiage : Pour briser et ameublir la surface d'un champ qui a été récolté, le scarifiage peut avoir un effet érosif.

Secteur protégé : Un secteur protégé dans une zone de terrain où des normes ou des restrictions sont imposées relativement aux activités d'utilisation des terres et de l'eau qui ont lieu dans ce secteur. Le secteur protégé existant désigné par le Décret de désignation de la marge de retrait des cours d'eau comprend la zone de retrait de 75 m autour des cours d'eau. La phase II du Programme de protection des bassins hydrographiques propose de redéfinir le secteur protégé afin qu'il englobe toute la zone du bassin hydrographique.

Vie aquatique : Espèces animales et végétales qui habitent pendant une partie ou la totalité de leur vie dans un milieu aquatique, comme le poisson, les amphibiens et les invertébrés aquatiques.

Zone de retrait : Cette zone de terrain est située à 75 m ou moins des rives de tous les cours d'eau à l'intérieur d'un bassin hydrographique, et désignée comme secteur protégé en vertu du Décret de désignation de la marge de retrait des cours d'eau. Il existe des normes rigoureuses concernant les activités d'utilisation des terres et de l'eau dans la zone de retrait.

Annexe B :

Bureaux du ministère de l'Environnement et des Gouvernements locaux

Bureau central
Ministère de l'Environnement et des Gouvernements locaux du Nouveau-Brunswick
C.P. 6000, E3B 5H1
20, rue McGloin
Fredericton (Nouveau-Brunswick) E3B 5H1
Tél. : 506 457-4846
Téléc. : 506 457-7823

Région 1
Courriel : elg.egl-region1@gnb.ca

BATHURST
159, rue Main, bureau 202
Bathurst (Nouveau-Brunswick) E2A 1A6
Tél. : 506 547-2092
Téléc. : 506 547-7655

CAMPBELLTON
157, centre municipal, rue Water
Campbellton (Nouveau-Brunswick) E3N 3L4
Tél. : 506 789-2353
Téléc. : 506 789-4878

TRACADIE-SHEILA
3518 - 2, rue Main
Tracadie-Sheila (Nouveau-Brunswick) E1X 1G5
Tél. : 506 394-3868
Téléc. : 506 394-3897

Région 2
Courriel : elg.egl-region2@gnb.ca

MIRAMICHI
316, avenue Dalton
Miramichi (Nouveau-Brunswick) E1V 3N9
Tél. : 506 778-6032
Téléc. : 506 778-6796

Région 3
Courriel : elg.egl-region3@gnb.ca
MONCTON
428, rue Collishaw
Moncton (Nouveau-Brunswick) E1C 3C7
Tél. : 506 856-2374
Téléc. : 506 856-2370
RICHIBUCTO
Édifice provincial
9239, rue Main
Richibucto (Nouveau-Brunswick) E4W 5R5
Tél. : 506 523-7604
Téléc. : 506 523-7648

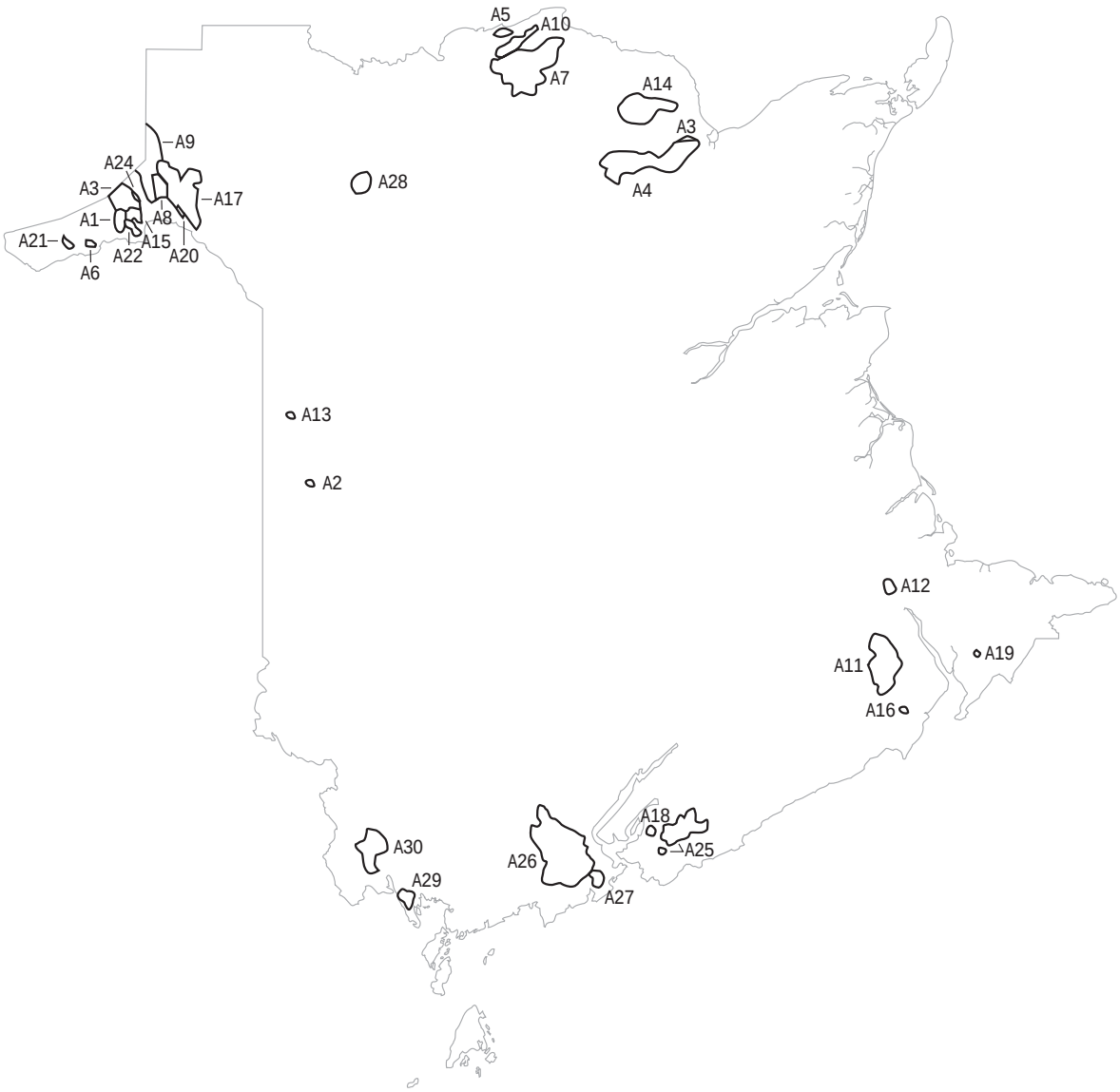
Région 4
Courriel: elg.egl-region4@gnb.ca
SAINT-JEAN
8, rue Castle
Saint-Jean (Nouveau-Brunswick) E2L 3B8
Tél. : 506 658-2558
Téléc. : 506 658-3046
ST. STEPHEN
Édifice provincial
41, rue King.
St. Stephen (Nouveau-Brunswick) E3L 2C1
Tél. : 506 466-7370
Téléc. : 506 466-7373
HAMPTON
27, promenade Centennial, Unité 2
Édifice du centenaire
Hampton (Nouveau-Brunswick) E5N 6N3
Tél. : 506 832-6000
Téléc. : 506 832-6007

Région 5
Courriel : elg.egl-region5@gnb.ca
FREDERICTON
Centre Priestman, bureau 103
565, rue Priestman
Fredericton (Nouveau-Brunswick) E3B 5X8
Tél. : 506 444-5149
Téléc. : 506 453-2893

Région 6
Courriel : elg.egl-region6@gnb.ca
GRAND FALLS
65, boulevard Broadway
Grand-Sault (Nouveau-Brunswick) E3Z 2J6
Tél. : 506 473-7744
Téléc. : 506 475-2510
EDMUNDSTON
121, rue Church, 3e étage
Carrefour Assomption
Edmundston (Nouveau-Brunswick) E3V 3L3
Tél. : 506 735-2763
Téléc. : 506 735-2093
WOODSTOCK
113, rue Cedar, bureau 213
Woodstock (Nouveau-Brunswick) E7M 2Y3
Tél. : 506 325-4465
Téléc. : 506 325-4541

Nota : Les adresses postales peuvent être différentes des adresses de voirie. Prière de vérifier auprès du bureau régional de votre choix pour confirmer l'adresse postale.

Carte des bassins hydrographiques désignés



Annexe C : Liste des bassins hydrographiques désignés

Municipalité	N° de carte	Bassin hydrographique
Baker Brook	A-1	Bassin hydrographique du ruisseau à Zépherin
Bath	A-2	Bassin hydrographique d'un affluent sans nom de la rivière Saint-Jean
Bathurst	A-3	Bassin hydrographique du ruisseau Carters
	A-4	Bassin hydrographique de la rivière Middle
Campbellton	A-5	Bassin hydrographique du lac Prichard – lac Smith
Clair	A-6	Bassin hydrographique du ruisseau Thompson
Dalhousie	A-7	Bassin hydrographique de la rivière Charlo
Edmundston	A-8	Bassin hydrographique du ruisseau à Blanchette
	A-9	Bassin hydrographique de la rivière Iroquois
Eel River Crossing	A-10	Bassin hydrographique de la rivière Eel
Moncton	A-11	Bassin hydrographique du ruisseau Turtle
	A-12	Bassin hydrographique du réservoir du chemin McLaughlin
Perth-Andover	A-13	Bassin hydrographique du ruisseau Huds
Petit-Rocher	A-14	assin hydrographique de la rivière Nigadoo
Verret	A-15	Bassin hydrographique du ruisseau Trois-Milles
Riverside-Albert	A-16	Bassin hydrographique de Arabian Vault Brook
Rivière-Verte	A-17	Bassin hydrographique de Rivière-Verte en aval de l'embouchure de Little Forks Branch Rivière verte uniquement
Rothesay	A-18	Bassin hydrographique de Carpenter Pond
Sackville	A-19	Bassin hydrographique du ruisseau Ogden Mill
Saint-Basile	A-20	Bassin hydrographique de l'affluent sans nom du ruisseau Des Smyth
Saint-François-de-Madawaska	A-21	Bassin hydrographique de l'affluent sans nom du fleuve Saint-Jean
Saint-Hilaire	A-22	Bassin hydrographique du ruisseau à Félix-Martin
Saint-Jacques	A-23	Bassin hydrographique de la rivière à la Truite
	A-24	Bassin hydrographique de l'affluent sans nom de la rivière Madawaska
Saint-Jean	A-25	Bassin hydrographique de Loch Lomond
	A-26	Bassin hydrographique de East et West Musquash
	A-27	Bassin hydrographique du lac Spruce
Saint-Quentin	A-28	Bassin hydrographique du ruisseau Five Fingers
St. Andrews	A-29	Bassin hydrographique du lac Chamcook
St. Stephen	A-30	Bassin hydrographique du ruisseau Dennis

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