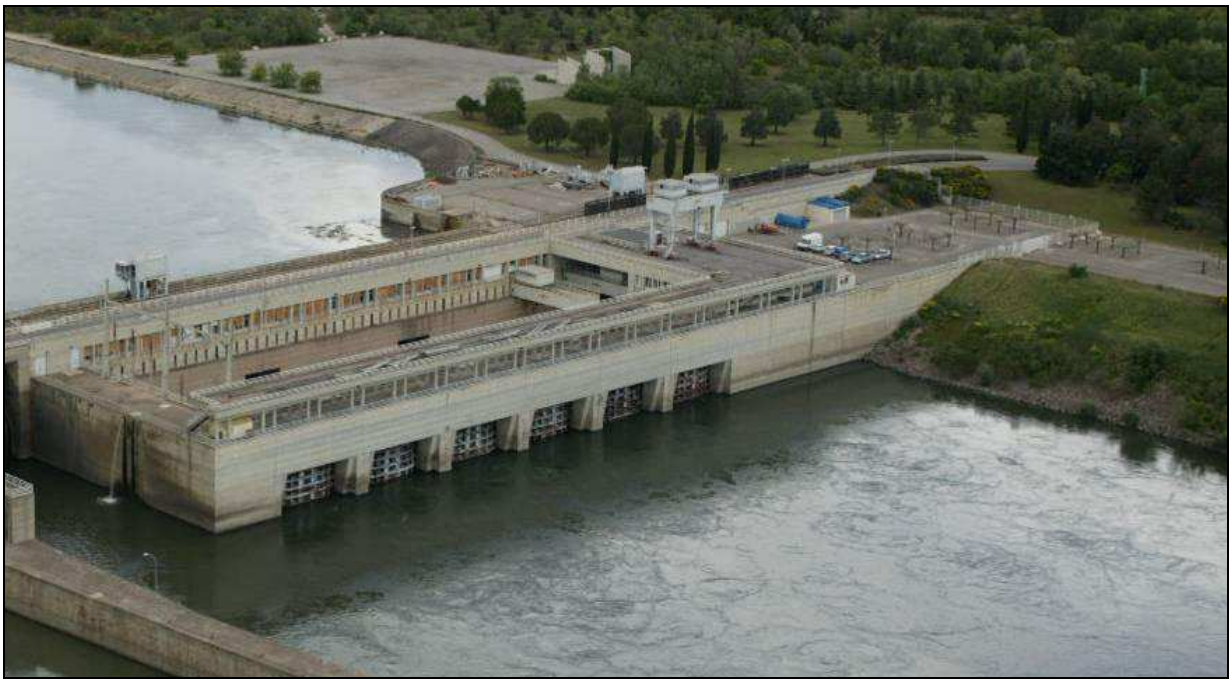
Compagnie Nationale du Rhône

Normandeau Associates, Inc

ANGUILLES-OUVRAGES

PROGRAMME NATIONAL DE RECHERCHE-DEVELOPPEMENT 2008-2009



EVALUATION DES TAUX DE SURVIE ET DE BLESSURES DES ANGUILLES PASSANT A TRAVERS UNE TURBINE DE GRANDE TAILLE A LA CENTRALE HYDROELECTRIQUE DE BEAUCAIRE SUR LE RHONE.

RAPPORT FINAL - MAI 2011 -

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Depuis plusieurs décennies, l'anguille européenne (Anguilla anguilla) présente de nets signes de déclin de son abondance sur l'ensemble de son aire de répartition (Dekker, 2004). Elle fait aujourd'hui partie des espèces menacées et au vu des bilans la situation est aujourd'hui devenue critique. Plus qu'un facteur en particulier, c'est une multiplicité de facteurs qui sont à l'origine de cette diminution continue. Il est donc essentiel de réduire significativement les pressions qui pèsent sur le stock (pêche et aspects environnementaux), mais aussi d'intervenir sur les obstacles à sa libre circulation qui constituent l'un des principaux facteurs limitant son aire de répartition en milieu continental avec des blocages à la montaison et des dommages lors de la dévalaison (dommages et mortalités suite au passage au travers des turbines).

Afin de restaurer le stock d'anguille, l'Union européenne a pris des mesures de protection au travers du règlement CE n° 1100/2007 du 18 septembre 2007. Le récent règlement européen pour la reconstitution du stock d'anguilles a défini un objectif d'atteindre un taux d'échappement de géniteurs équivalent à 40% de la biomasse « pristine » (état naturel sans pression anthropique impactant le stock).

Le Ministère de l'Ecologie, de l'Energie, du Développement Durable et de l'Aménagement du Territoire ainsi que le Ministère de l'Agriculture et de la Pêche ont été chargés de mettre en place un Plan de Gestion national pour la reconstitution du stock d'anguilles comportant des mesures sur les différents facteurs de mortalités anthropiques. Afin de mener à bien ce Plan de Gestion, un Comité National Anguille a été mis en place, ainsi que plusieurs groupes de travail thématiques, dont le groupe de travail « Ouvrages ».

Le **groupe de travail « Ouvrages »** a rendu un rapport validé par le Comité National le 9 janvier 2008. Celui-ci a conclu notamment à l'intérêt de la mise en œuvre d'un programme de Recherche et de Développement qui a pour objectif la mise en œuvre d'un certain nombre d'actions visant à acquérir une meilleure connaissance du comportement et des rythmes de dévalaison de l'anguille, à évaluer l'impact des aménagements hydroélectriques à la dévalaison (mortalités dans les turbines et impacts cumulés des aménagements sur un axe donné), à développer et évaluer de nouvelles techniques visant à réduire les mortalités dans les turbines

(prises d'eau ichtyocompatibles, turbines ichtyophiles, biomoniteurs, barrières comportementales).

Dans ce contexte un certain nombre **d'actions communes de Recherche et Développement** sur le franchissement des ouvrages par l'anguille européenne ont été engagées en 2008 et 2009, actions qui ont fait l'objet d'un **accord cadre** signé par les principaux acteurs : Electricité de France, France Hydroélectricité, GDF-SUEZ, la Compagnie Nationale du Rhône, la Société Hydroélectrique du Midi, l'ADEME et l'ONEMA.

La présente étude est issue de cet accord-cadre et constitue l'**action n°16** de ce programme.

Elle a été réalisée localement dans le cadre partenarial du **PLAN RHONE** et de son volet « qualité des eaux, ressources et biodiversité », en réponse à la mise en place de la stratégie migrateurs sur le Rhône.

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RESUME

Les probabilités de survie (à 1 et 48 h) des anguilles européennes adultes, *Anguilla anguilla*, ont été estimées lors du passage à travers une turbine à 4 pales, de type bulbe, de l'usine hydroélectrique de Beaucaire, sur le Rhône dans le sud de la France. Les anguilles avaient une taille comprise entre 570 mm et 1040 mm pour une moyenne de 686 mm. L'étude a utilisé le système de marquage à ballons HI-Z (HI-Z tag) et s'est déroulée du 6 au 15 septembre 2010 dans des eaux dont la température à varié de 19,0 à 23,5 ° C. Un total de 275 anguilles a été libéré au moyen d'un dispositif injection devant le groupe 3 à deux profondeurs différentes (0,5 m et 3.5 m en dessous du plafond d'admission correspondant respectivement à l'extrémité supérieure de la pale et au centre de la pale. 50 anguilles témoins ont été relâchées via une rampe d'injection identique à l'aval de l'usine.

Les taux de recapture (récupération physique des anguilles vivantes et mortes) étaient élevés pour les deux points d'injections : 96,4 % pour le haut de pale et 95,1% pour le milieu. La plupart des anguilles ont été capturées dans les 10 minutes après leur injection. La combinaison d'un taux de recapture élevé et du fort taux de survie des anguilles témoins (100%) a fourni une estimation statistiquement représentative de la survie des anguilles adultes passant par une turbine de l'usine hydroélectrique de Beaucaire.

Le taux de survie au bout d'une heure était de 95,5% en haut de pale et 95,7% en milieu de pale avec une valeur moyenne de 95,6%. Le taux de survie au bout de 48 h était respectivement de 93,7 et 91,4% pour le haut et le milieu de pale, la valeur moyenne était de 92,3%. Les incertitudes (1 et 48 h) étaient toutes deux de ± 4%, 90% du temps et l'incertitude moyenne était de ± 3%, 90% du temps. L'incertitude cible de ± 5%, 90% du temps à chaque endroit de passage a été atteinte.

Les taux d'anguilles saines (exemptes de blessures visibles et sans perte d'équilibre) injectées en amont de l'usine hydroélectrique de Beaucaire ont été relativement élevés. Le taux d'anguilles saines injectées en milieu de pale était de 92,3%, et de 90,7% pour celles injectées en haut de pale. Le taux moyen d'anguilles saines était de 91,6%.

La principale lésion correspondait à des ecchymoses sur la tête et le corps et a été attribuée à des causes mécaniques résultant de heurts avec les pales ou de contact direct avec d'autres composants structuraux lors du passage dans la turbine. Les taux de survie et d'anguilles saines à Beaucaire ont été similaires à ceux obtenus pour les anguilles adultes de taille comparable passées à travers une turbine Kaplan 4 pales à la l'usine hydroélectrique de Fessenheim. A ce jour, les groupes bulbes à Beaucaire semblent être plus favorables aux poissons de grande taille que la plupart des autres turbines Kaplan / turbines à hélice, évaluées par la même technique (système de marquage à ballons HI-Z et récupération directe).

1. INTRODUCTION

Ce dossier est la traduction française du rapport de synthèse rédigé en avril 2011 par le bureau d'étude américain Normandeau en charge de cette étude sur le plan scientifique.

Les figures, tableaux et annexes cités dans le texte sont situés dans le rapport original de Normandeau fourni en pièce jointe.

La mortalité globale des poissons ou des anguilles entraînés dans les turbines hydroélectriques est due à deux éléments principaux : des effets directs et des effets indirects :

Les effets directs (notamment ceux induits mécaniquement et ceux liés à la pression, à la cavitation ou au cisaillement) se manifestent immédiatement après le passage dans la turbine sous forme de mortalité instantanée des poissons, de blessures et de pertes d'équilibre.

Les effets indirects (notamment la prédation, les maladies, le stress physiologique, etc.) peuvent se manifester à plus long terme ou sur une plus longue distance en amont après le passage dans la turbine.

La Compagnie Nationale du Rhône, (CNR) a cherché à obtenir une estimation des effets directs du passage dans la turbine de la centrale électrique de Beaucaire sur des anguilles européennes adultes (*Anguilla anguilla*).

1.1. Description du projet

La centrale électrique de Beaucaire (Figure 1-1) est située sur le Rhône, dans le sud de la France, au nord d'Arles et de Marseille, sa latitude est de 43.824N et sa longitude est de 4.644E. Opérationnelle depuis 1970, Vallabrègues est la dernière centrale électrique sur le Rhône avant la Méditerranée. Cette installation comprend trois ouvrages : le barrage de Vallabrègues, la centrale hydroélectrique et l'écluse de Beaucaire. La centrale de Beaucaire est équipée de 6 groupes-bulbes. Chaque turbine comporte quatre pales pivotant à la vitesse de 94 tours/min. La hauteur opérationnelle de chute est d'environ 14 m et le diamètre de la roue la turbine est de 6.24 m (Tableau 1-1). La capacité de production hydroélectrique de la centrale de Beaucaire est de 210 MW avec une production annuelle moyenne de 1 300 000 000 kWh. Cela correspond approximativement à la consommation électrique annuelle de la ville de Nice. L'écluse mesure 190 m de long et 12 m de large, avec une hauteur de chute de 16 m.

2. PLAN D'ETUDE

2.1. Objectifs

Les principaux objectifs de l'étude étaient d'évaluer les taux de survie directe (à 1 h et à 48 h) et d'absence de maladie (anguilles sans blessures apparentes et sans perte d'équilibre) des anguilles européennes adultes (Anguilla anguilla) passant à deux endroits différents dans la turbine de l'Unité 3 de la centrale de Beaucaire, en utilisant la technique de recapture du poisson avec marquage de type HI-Z Turb'N (HI-Z) (Heisey *et al*. 1992). Les anguilles ont été relâchées de manière à ce que le trajet prévu se trouve près de l'extrémité de la pale ou près de son milieu (milieu). Les anguilles ont été relâchées à 0,5 m sous le plafond de la prise d'eau pour diriger les anguilles vers l'extrémité de la pale et à 3,5 m sous le plafond pour diriger les anguilles vers le milieu de la pale (Figure 2-1 et 2-2). Une fois passées, les anguilles vivantes et les anguilles mortes ont été comptabilisées et la présence de blessures a été recherchée sur chaque anguille. Les taux de survie et d'absence de maladie ont été estimés à chaque point de passage et aux endroits combinés. Les descriptions des blessures observées ont été consignées pour mieux évaluer les causes probables des blessures ou de la mortalité susceptibles d'être ensuite utilisés pour identifier des mesures potentielles d'atténuation.

2.2. Conditions de fonctionnement

Les paramètres physiques et opérationnels mesurés pendant le relâcher des anguilles dans l'Unité 3 sont présentés sur le tableau 2.1. Le débit de l'Unité 3 était d'environ 313 m³/s au barrage de Beaucaire. La production était de l'ordre de 35 MW pour l'Unité 3 et la hauteur opérationnelle de chute d'environ 14 m. Le débit total de la centrale de Beaucaire approchait 1200 m³/s pendant l'étude. La turbine de l'Unité 3 a été testée selon les paramètres de fonctionnement les plus courants de l'unité pour évaluer des conditions types.

2.3. Calculs du nombre d'échantillons

Avant le début de l'étude, le nombre d'échantillons a été défini pour répondre à l'objectif principal qui était d'obtenir des estimations de taux de survie et d'absence de maladie en deçà d'un niveau de précision (ε) prédéterminé. Le nombre d'échantillons est un élément du taux de recapture (P_A), de la survie prévue au passage de la turbine ($\hat{\tau}$) ou de la mortalité ($1-\hat{\tau}$), de la survie des anguilles témoins (S) et de la précision souhaitée (ε) avec une probabilité de signification donnée (α). D'une manière générale, le nombre d'échantillons nécessaires diminue avec une augmentation de la survie des anguilles témoins, non malades et des taux de recapture (Mathur *et al.* 1996, 2000 et tableau 2-2). Seuls la précision et le niveau α peuvent être strictement contrôlés par un chercheur. Les résultats d'une précédente étude de survie directe à la traversée de la turbine sur les anguilles indiquent qu'un nombre d'échantillons d'environ 350 anguilles (300 anguilles de traitement et 50 anguilles témoins) serait suffisant pour obtenir des estimations de survie de ± 0,05 dans 90% du temps, dans certaines conditions de fonctionnement. Ce nombre suppose une survie des anguilles témoins proche de 100%, un taux de recapture de 95% et des taux prévus de survie au passage de la turbine et d'absence de maladie > 85% pour une étude spécifique. Avec une survie des anguilles témoins, des taux de recapture et une survie au passage de la turbine similaires, la précision de ± 0,10 dans 90% du temps

sur les estimations de survie devrait être réalisable pour chacun des deux points de passage (à l'extrémité et au milieu). Au total 275 anguilles de traitement ont été relâchées dans la prise d'eau de la turbine et 50 anguilles témoins ont été relâchées dans le point de restitution pendant l'étude (Tableau 2-3).

2.4. Origine et conservation des spécimens

Les anguilles de cette étude ont été capturées à l'aide de verveux tendus sur le Rhône par un pécheur professionnel. Les stations de capture étaient situés en aval d'Arles (Mas Tibbert) à 30 km en aval de Beaucaire et sur la partie amont de la retenue de Caderousse à 45 km en amont de Beaucaire. Les poissons ont été transportés dans un fourgon équipé d'un casier à poisson avec circulation d'eau et livrés dans deux viviers situés dans le point de restitution (Figures 2-3 et 2-4). Ces viviers contenaient environ 5000 L d'eau. Tous les viviers étaient placés à l'intérieur d'une zone couverte et ombragée près de la salle de commande. Seules les anguilles en bonne condition sanitaire ont été utilisées pour cette étude. Chaque vivier a été alimenté en permanence avec de l'eau du Rhône à température ambiante et tous les poissons y ont séjourné pendant au moins 12 à 24 h avant d'être marqués, ce qui a donné aux poissons le temps de se remettre de la capture initiale et du stress dû à la manipulation. Les températures de l'eau dans les viviers étaient comparables aux températures du fleuve, de 20,8 à 23°C. Les 275 anguilles de traitement relâchées mesuraient entre 580 mm et 1040 mm, avec une taille moyenne de 686 mm (Figure 2-5). Les 50 anguilles témoins relâchées mesuraient entre 590 mm et 900 mm, avec une taille moyenne de 697 mm. La taille moyenne des anguilles d'expérimentation et témoins combinées était de 690,5 mm.

2.5. Marquage et injection (relâcher)

Afin de guider les anguilles de grande taille vers la surface pour permettre une recapture rapide, quatre à six étiquettes à ballon HI-Z ont été fixées avec un petit collier de serrage qui traverse le muscle à deux ou trois endroits le long du dos de l'anguille par le biais d'une aiguille à canule incurvée (Figures 2-6 et 2-7). Des émetteurs ont été fixés et combinés à l'une des étiquettes HI-Z pour permettre de suivre le déplacement des anguilles relâchées. Des dispositifs de retenue spécifiques développés et construits par Normandeau permettent d'étiqueter les anguilles d'expérimentation (Figure 2-8).

En plus du dispositif de retenue, les anguilles ont été soumises à un appareil d'anesthésie électrique pendant la pose de l'étiquette. L'appareil d'anesthésie électrique (EAU) utilisé dans cette étude était un Endomorph EA-60 fabriqué par Marine Electrics (Ireland) Ltd., Killybegs, County Donegal, Irlande. L'EAU se composait de deux plaques rectangulaires en acier inoxydable (anode et cathode), reliées à un boîtier de commande et alimentées par une batterie de moto de 12 volts et 7 ampères. Les anguilles ont été alignées perpendiculairement aux plaques d'électrodes, leurs têtes et queues orientées respectivement vers l'anode et vers la cathode, avant l'application du courant.

Les anguilles ont été marquées et identifiées individuellement avec de petites étiquettes Floy numérotées. Les étiquettes Floy tubulaires ont été insérées dans le muscle sous la partie antérieure de la nageoire dorsale. Juste avant le relâcher, les étiquettes HI-Z ont été activées par l'injection d'une

petite quantité d'eau dans l'étiquette HI-Z, ce qui fait gonfler l'étiquette à peu près en 2 à 4 minutes. Les étiquettes ont été activées alors que l'anguille se trouvait encore dans le dispositif de retenue et le poisson a été relâché (Figures 2-9 à 2-11).

Toutes les anguilles ont été relâchées à travers des systèmes d'injection construits par EDF d'après les plans de Normandeau (Figure 2-12) et alimentés en eau du Rhône par des pompes de 60 m3/h. La table d'injection était connectée à des tuyaux de 10,2 cm de diamètre qui permettaient aux anguilles de passer librement vers les points de relâcher souhaités, tant pour les poissons de traitement et les poissons témoins. Les tuyaux de d'injection des anguilles de traitement étaient fixés à un palonnier en acier qui a été descendu dans le pertui au-dessus de la prise d'eau (Figure 2-13). Le palonnier et les deux tuyaux ont été descendus jusqu'à ce que l'extrémité de l'un des tuyaux soit à 0,5 m en-dessous du plafond de la prise d'eau et celle de l'autre tuyau à 3,5 m en dessous du plafond de la prise d'eau. Le palonnier était maintenu juste au-dessus du plafond et en dehors du flux dirigé vers la turbine (Figure 2-2). Ces points d'injection ont été prévus pour rapprocher les anguilles respectivement de l'extrémité supérieure de la pale de la turbine et du milieu de la pale, lorsque les anguilles suivent le flux à l'intérieur de la turbine**.** Chaque tuyau de d'injection était approvisionné en continu en eau du Rhône pour garantir le transport rapide des anguilles vers le point de d'injection prévu. Des anguilles témoins ont été relâchées à travers un système d'injection identique fixé à un tuyau flexible de 10,2 cm de diamètre qui permettait de relâcher le poisson à l'intérieur du point de restitution en aval immédiat de la centrale (Figure 2-3).

Les procédures de manipulation, d'étiquetage, d'injection et de recapture des anguilles étaient similaires pour les groupes de traitement et les groupes témoins. Les anguilles ont été sélectionnées au hasard à l'aide d'épuisettes dans les viviers situés sur le pont d'admission. Seules les anguilles en bonne condition sanitaire ont été utilisées. Les autres étaient remises au fleuve en aval de l'usine.

2.6. Méthodes de recapture des anguilles

Après relâcher (qu'il s'agisse des anguilles de traitement ou des anguilles témoins), les anguilles ont été repérées puis récupérées une fois remontées à la surface en amont de la centrale de Beaucaire par l'un des trois équipes de recapture (Figure 2-14). Les équipes ont été informées de la fréquence de l'émetteur radio de chaque anguille lors de son relâcher. Les signaux radio ont été réceptionnés sur une antenne de type Yagi à 5 éléments ou antenne de type Loop couplée à un récepteur ATS (Advanced Telemetry System) (Figure 2-15). La transmission des signaux radio (48 ou 49 MHz) a permis aux équipes de suivre les mouvements de chaque anguille après leur passage dans la turbine et de positionner les bateaux en aval pour récupérer les anguilles remontées à la surface (Figure 2-16 à 2-18). Les anguilles remontées à la surface et qui restaient bloquées au pied de la centrale en raison des contre-courants ont été capturées par un carrelet déployé à partir du haut de la centrale.

Les poissons recapturés ont été placés dans un vivier embarqué (Figure 2-19) et toutes les étiquettes ont été enlevées à l'exception de l'étiquette Floy. La présence de maladies, notamment de blessures apparentes, d'une perte d'équilibre (LOE) a été vérifiée sur chaque anguille ainsi que les codes

attribués à chaque état (Tableau 2-4). Le personnel chargé de l'étiquetage et de l'enregistrement des données a été informé par un système de radio bidirectionnel de l'heure et des conditions de recapture de chaque anguille.

Les anguilles recapturées ont été transportées sur la rive et rapatriées à la centrale et placées dans des viviers (5000 litres) afin de surveiller les effets différés (48h) de l'étiquetage et du passage dans la turbine. Les viviers étaient alimentés constamment en eau du Rhône à température ambiante et abrités par un filet d'ombrage permettant aussi d'empêcher une fuite ou une prédation potentielle des anguilles. Les anguilles encore vivantes 48 h après et sans blessures importantes ont été relâchées dans le fleuve en aval de l'usine.

2.7. Evaluation des blessures

Les types et étendues des blessures externes ont été examinés sur toutes les anguilles recapturées, vivantes ou mortes (Figures 20 à 23). Les anguilles mortes ont également été autopsiées pour vérifier la présence de blessures internes lorsqu'il n'y avait pas de blessures apparentes externes. Les blessures ont été classées par type, étendue et zone corporelle. Les anguilles sans blessures apparentes mais qui ne nageaient pas de manière active ou nageaient de manière irrégulière lors de leur recapture ont été classées comme souffrant d'une "perte d'équilibre". Cet état a été constaté dans la plupart des précédentes études avec étiquettes HI-Z sur la survie ou les blessures directes et disparaît souvent dans les 10 à 15 minutes qui suivent la recapture si le poisson n'est pas blessé. Les blessures apparentes et la LOE ont été cataloguées de mineures ou majeures. Les critères de détermination reposent surtout sur les observations faites sur place par le personnel de Normandeau (Tableau 2-5).

Une classification des maladies a été établie pour inclure les anguilles avec blessures apparentes, ecchymoses (≥ 20% de chaque côté) ou LOE. Les anguilles ne présentant pas de maladies ont été déclarées « non malades ». Le critère d'évaluation de cette absence de maladie est établi afin de fournir un mode standard de description des effets spécifiques du passage dans la turbine sur l'état des poissons entraînés (Normandeau Associates and Skalski 2006). Ce critère d'évaluation repose uniquement sur des poissons recapturés et examinés physiquement. De plus, le critère d'évaluation d'absence de maladie, associé à des données hydrauliques et physiques spécifiques, permet de mieux connaitre les conditions et points de passage plus sécurisés pour les poissons.

2.8. Classification des poissons recapturés

Comme l'indiquent de précédentes recherches (Mathur *et al*. 1996, 2000 Normandeau Associates 2010; Normandeau and Skalski 1998 et 2006; North/South Consultants Inc. and Normandeau Associates Inc. 2007, 2009), l'état dans lequel se trouve une anguille recapturée immédiatement après son passage dans la turbine et la récupération des étiquettes gonflées détachées de l'anguille été qualifié de vivant, mort ou inconnu.

Les critères de détermination en sont les suivants :

(1) vivant – poisson recapturé vivant et qui le reste pendant 1 h ;
(2) vivant – le poisson ne remonte pas à la surface mais les signaux radio indiquent des mouvements ; (3) mort – recapturé mort ou mort dans l'heure qui suit l'injection ;
(4) mort – seules la ou les étiquettes gonflées et détachées sont récupérées et/ou le traçage télémétrique ou la manière dont les étiquettes gonflées sont remontées à la surface n'indiquent pas que le poisson est vivant ;
(5) inconnu – aucun poisson et aucune étiquette ne sont recapturés, ou bien la réception des signaux radio est brève, ce qui ne permet pas de déterminer l'état du poisson avec certitude.

Les anguilles qui ont migré dans des zones où il n'était pas possible de les capturer (par exemple un enrochement le long de la rive, des crevasses submergées et des zones de forte turbulence) n'ont pas été prises en compte dans l'analyse statistique. Au cours de la présente étude, seules deux anguilles ont migré dans une zone ne permettant pas de les recapturer en toute sécurité.

La mortalité survenant dans l'heure suivant la capture des anguilles a été déclarée comme un effet survenant dans les 48 h suivant le passage dans les turbines bien que les anguilles aient été observées à des intervalles d'environ 12 h. Des ecchymoses et des blessures ont été recherchées sur des anguilles mortes et celles qui sont mortes sans blessures apparentes ont été autopsiées pour déterminer la cause probable de la mort. De plus, tous les spécimens vivants après 48 h ont fait l'objet d'une recherche approfondie d'éventuelles blessures. L'examen initial a permis de détecter certaines blessures comme un saignement ou une ecchymose mineure qui pouvait ne pas être visible après 48 h en raison du processus naturel de cicatrisation.

2.9. Estimation de la survie et de l'absence de blessures

Les probabilités de survie séparées (à 1 et à 48 h), les estimations d'absence de blessures et leurs erreurs standards potentielles ont été évaluées selon le modèle de probabilité donné dans Mathur *et al*. (1996) and Normandeau Associates Inc. and Skalski 1998. Les formules s'appliquent à :

La survie directe, à 1 heure et à 48 heures, où :

$$\hat{\tau}_i = \frac{a_{Ti} R_c}{R_{Ti} a_c},$$

R_{Ti} = nombre de poissons relâchés pour le traitement
a_{Ti} = nombre de poissons vivants pour le traitement (i = 1,...,9) ;
R_c = nombre de poissons témoins relâchés ;
a_c. = nombre de poissons témoins vivants ;

L'absence de blessure (MF), où :

$$MF_i = \frac{c_{Ti} R_c}{R_{Ti} c_c},$$

C_{Ti} = nombre total de poissons non blessés pour traitement i (i = 1,...,9) ;
R_{Ti} = nombre de poissons récupérés et examinés pour détecter des blessures pour traitement i (i = 1,...,9) ;
C_c = nombre de poissons témoins récupérés non blessés ;
R_c = nombre de poissons témoins récupérés et examinés pour détecter des blessures.

Un test t a été effectué pour déterminer si la survie et/ou les blessures étaient liées au point de passage ou à la longueur de l'anguille. Niveau de signification affecté P = 0,10 pour tous les essais statistiques.

2.10. Attribution des origines probables de la blessure

Des expériences contrôlées limitées (Neitzel *et al*. 2000; Pacific Northwest National Laboratory et al. 2001) pour reproduire et mettre en corrélation chaque type/caractéristique de blessure avec un mécanisme de cause à effet spécifique donnent une indication de la cause des blessures observées sur place. Certains symptômes de blessures peuvent avoir deux origines différentes susceptibles de diminuer la probabilité de description précise d'une relation de cause à effet (Eicher Associates 1987). Seuls des mécanismes probables de cause à effet de la blessure ont été attribués à la présente étude.

Certaines blessures (notamment des corps tranchés) peuvent être attribuées à une source spécifique de cause à effet avec une plus grande certitude (Normandeau Associates *et al*. 1995). Des blessures pouvant être associées au contact direct des pales de la turbine ou à des composants de la structure sont qualifiées de mécaniques et incluent : les ecchymoses, la lacération et le morcellement du corps des poissons (Dadswell *et al*. 1986; Eicher Associates 1987; RMC and Skalski 1994a, b). Le corps des poissons peut être pincé au passage dans des espaces entre les pales de la turbine et le moyeu ou à l'extrémité distale (Normandeau Associates *et al*. 1995). Le contact avec les composants de la turbine peut provoquer des ecchymoses. Les blessures pouvant être attribuées à des forces de cisaillement sont la décapitation, la déchirure ou l'éclatement des opercules et l'hémorragie des yeux (Dadswell *et al*. 1986). Les effets probables liés à la pression se manifestent sous forme d'hémorragie interne des organes, toutefois les efforts liés à la pression peuvent également provoquer le gonflement et l'hémorragie des yeux. Vous trouverez dans l'Annexe A des informations détaillées sur les opérations effectuées dans la centrale, dans l'Annexe B des données détaillées de recapture avec étiquettes, dans l'Annexe C une analyse statistique, dans l'Annexe D des données individuelles sur les poissons et dans l'Annexe E des photos de blessures.

3. RESULTATS

3.1. Taux de recapture

La technique de recapture avec étiquette HI-Z s'est avérée satisfaisante avec des taux de recapture généralement élevés (récupération physique d'anguilles vivantes et d'anguilles mortes). Les anguilles européennes adultes ont traversé la turbine de l'Unité 3 fonctionnant à environ 35 MW et avec un débit d'environ 300 m³/s (Tableau 2.1). Des anguilles témoins ont été relâchées dans le point de restitution en aval de la centrale. Les anguilles ont été relâchés pendant sept jours entre le 6 et le 13 septembre 2010 et les injections étaient principalement concentrés sur des points situés à l'extrémité et au milieu des pales de la turbines (Tableau 2-3). Le taux d'anguilles recapturées était élevé : 100% des anguilles témoins et 94,9% des anguilles de traitement (Tableau 3-1). Pour 10 anguilles de traitement (3,6%), seuls les ballonnets des étiquettes HI-Z ont été recapturées et rien n'a été recapturé pour uniquement 2 anguilles de traitement (0,7%). Les anguilles dont seuls les ballonnets des étiquettes HI-Z ont été récupérées ont été déclarées mortes et celles dont rien n'a été recapturé ont été classées comme inconnues.

3.2. Délais de recapture

Les délais de recapture (intervalle entre le l'injection des anguilles et leur recapture) pour les deux groupes de traitement, à l'extrémité et au milieu de la turbine étaient respectivement de 4,2 et 5,8 minutes (Figure 3-1). Le délai moyen de recapture des anguilles témoins était de 7,7 minutes. Le délai maximum avant la recapture était de 197 minutes pour une anguille passant injectée en milieu de pale.

3.3. Estimations de survie

La survie directe à 1 h était de 95,5% (extrémité de pale) à 95,7% (milieu de pale) avec une valeur globale de 95,6% (Tableau 3-1). La survie à 48 h était respectivement de 93,7 et 91,4% pour les injections en extrémité et en milieu de pale, la valeur globale était de 92,3%. Cette estimation incluait les poissons encore vivants 48 h après mais considérés comme « fonctionnellement » morts (gravement blessés). La précision des estimations de survie (à 1 h et à 48 h) pour les injections à l'extrémité et au milieu de la pale était respectivement de ±3,8 et 3,6% dans 90% du temps. La précision des estimations globales était de ± 2,6% dans 90% du temps. La précision ciblée de ≤ ± 10,0% dans 90% du temps pour les estimations de survie à chaque point de passage était atteinte ainsi que la précision ciblée de ≤ ± 5% dans 90% du temps pour les estimations globales. Les estimations de survie pour les poissons passant à l'extrémité et au milieu n'étaient pas très différentes ($P > 0.10$).

3.4. Taux, types et origine probable des blessures

Au total 263 des 275 anguilles de traitement ont été recapturées et la présence de blessures a été recherchée (Table 3-2). Parmi toutes les anguilles, 18 (6,8%) présentaient des blessures apparentes et 4 autres (1,5%) ne présentaient qu'une perte d'équilibre. Parmi les 112 anguilles relâchées et qui

sont passées près de l'extrémité de la pale, 108 (96,4%) ont été examinées, huit (7,4%) de celles-ci ont montré des signes apparents de blessures liées au passage. Deux (1,9%) n'ont présenté qu'une perte d'équilibre. Les taux de blessures étaient identiques pour les anguilles passées au milieu. Parmi les 163 anguilles injectées en milieu de pale, 155 (95,1%) ont été examinées et 10 (6,5%) ont montré des signes apparents de blessures liées au passage ; 2 poissons supplémentaires n'ont présenté qu'une perte d'équilibre.

Les principales blessures observées sur les anguilles passées à l'extrémité étaient des ecchymoses à la tête et le long du corps (4,6%, Tableaux 3-3 et 3-4 et Figures 20 à 23). Deux anguilles étaient coupées (1,9%), une anguille saignait des branchies et une autre avait sa grande arête brisée. Les types de blessures présentées par les anguilles passées au milieu étaient similaires à ceux des anguilles passées à l'extrémité. Sept (4,5%) des anguilles recapturées et passées au milieu présentaient des ecchymoses à la tête ou le long du corps, quatre (2,6%) saignaient des branchies, deux (1,3%) présentaient une hémorragie interne ou une grande arête brisée et une (<1%) présentait des coupures sérieuses. Les 80 anguilles témoins relâchées ont toutes été examinées et aucune n'était blessée.

Des causes mécaniques ont été attribuées à presque toutes les blessures observées (18 sur 22) sur les anguilles ayant traversé la turbine ; la cause n'a pas pu être déterminée pour quatre anguilles (Tableaux 3-4, 3-5). Il est probable que les blessures mécaniques ont été provoquées par un choc de la pale ou le contact avec d'autres éléments de structures sur la trajectoire. La plupart (17 sur 22) des blessures dues au passage de la turbine ont été considérées comme majeures et ont provoqué la mort ou ont été considérées comme un danger mortel.

3.5. Estimations concernant l'absence de blessure

Les estimations concernant l'absence de blessure (par exemple les poisons ne présentant pas de blessure liée au passage dans la turbine) sont indiquées dans le Tableau 3-2. Les taux d'estimations d'absence de blessures ont été équilibrés par les taux de blessures provoquées par l'essai témoin. Les estimations d'absence de blessures pour les anguilles adultes relâchées à l'extrémité de la pale de la turbine sont de 90,7% avec un IC de 90%, ± 4,6%. Les estimations d'absence de blessures pour les anguilles adultes relâchées au milieu de la pale de la turbine sont de 92,3% avec un IC de 90%, ± 3,5%. Les estimations globales pour les anguilles relâchées au milieu et à l'extrémité de la pale de la turbine sont de 91,6% avec un IC de 90%, ± 2.8%. La précision souhaitée (± 5% dans 90% du temps) sur les estimations d'absence de blessure a été atteinte. Les estimations d'absence de blessure pour les poissons passant par l'extrémité et le milieu de la pale n'étaient pas très différentes ($P > 0.10$).

3.6. Incidence de la taille sur la survie et sur les blessures

On a examiné l'incidence de la longueur de l'anguille sur les taux de survie et d'absence de blessure (Figures 3-2 et 3.3). Rien n'indiquait qu'un poisson plus gros présentait des taux inférieurs de survie ou d'absence de blessure. Cela peut être dû au faible nombre de poissons morts et blessés et au nombre limité de tailles des spécimens testés.

4. PRINCIPALES CONSTATATIONS ET DISCUSSION

Les principaux objectifs de l'étude de détermination de la survie et des blessures directes des anguilles adultes après passage d'une turbine de la centrale de Beaucaire ont été atteints. Les estimations de survie ou de blessures au passage de la turbine peuvent être considérées comme valables après vérification de certaines hypothèses sous-jacentes et l'utilisation d'un modèle approprié correspondant aux données (Burnham *et al*. 1987; Mathur *et al.* 1996).

Les hypothèses suivantes, principalement liées au processus de recapture avec étiquettes, ont été vérifiées : les procédures de manipulation, d'étiquetage et d'injection n'ont pas eu d'incidence distincte sur les taux de survie des groupes témoins et des groupes de traitement et, ces deux groupes ont été exposés à des conditions similaires au point de restitution. De plus, les étiquettes HI-Z n'ont pas gonflé avant le passage de la turbine et ont flotté de manière neutre jusqu'à ce qu'elles soient gonflées. Les anguilles étiquetées HI-Z auraient dû avoir les mêmes chances que les anguilles émigrant sans étiquettes d'être exposées à des forces mécaniques et de cisaillement et à des turbulences pendant le passage de la turbine. Une source potentielle d'erreur due à la récupération aléatoire de groupes de traitement et de groupes témoins a été minimisée par le fait qu'aucune équipe spécifique n'a été affectée à la recapture soit d'anguilles témoins soit d'anguilles de traitement.

Au total 275 anguilles de traitement ont été relâchées à la prise d'eau de la turbine et 50 anguilles témoins ont été relâchées dans le point de restitution pendant l'étude. Les 275 anguilles de traitement relâchées mesuraient de 580 mm à 1040 mm, avec une taille moyenne de 686 mm. Les 50 anguilles témoins mesuraient de 590 mm à 900 mm avec une taille moyenne de 697 mm.

La combinaison d'un taux de recapture des anguilles de traitement relativement élevé (95,6%) et d'une survie des anguilles témoins de 100% a permis d'obtenir des estimations de survie et de blessures valables et relativement précises. Les estimations de survie directe à 1 h pour des anguilles adultes après passage dans la turbine de l'Unité 3 étaient respectivement de 95,5% et de 95,7% pour les anguilles passées à l'extrémité et au milieu. Les estimations correspondantes à 48 h étaient de 93,7% et de 91,4% avec des estimations combinées de 92,3%.

Dix huit des 275 (6,8%) anguilles de traitement recapturées présentaient des blessures apparentes. Les blessures les plus courantes étaient des ecchymoses à la tête et au corps. La plupart (77%) des blessures infligées par la turbine étaient mortelles ou représentaient un danger mortel. La majorité des blessures semblait être due à des forces mécaniques associées à un choc de la pale et/ou au contact avec d'autres structures sur la trajectoire. Les estimations d'absence de maladie pour les poissons passant par l'extrémité et le milieu de la pale étaient relativement élevées (respectivement 90,7% et 92,3%) et l'estimation globale était de 91,6%.

Il existe trois risques principaux associés au passage de la turbine :

- 1 - des dommages mécaniques dus au contact direct avec les pales rotatives ou avec des composants de la structure ou au passage à travers des ouvertures ;
- 2 - un changement rapide de la pression de l'eau par rapport à l'historique de la pression d'acclimatation des poissons ;
- 3 - des forces hydrauliques de cisaillement ou de la cavitation.

Toutefois ces risques ne s'appliquent pas de manière universelle à toutes les espèces et à leurs cycles de vie ou à toutes les turbines. Une proportion distincte d'anguilles entraînées peut-être exposée à l'un de ces risques sur un site. (Heisey *et al*. 1992; Mathur *et al*. 1996; Normandeau Associates *et al*. 1995). Les blessures d'origine mécanique sont surtout fonction du nombre de pales, de la vitesse de rotation et de la taille du poisson par rapport au diamètre de la pale de la turbine.

Il existe peu d'informations sur les taux de survie d'une anguille adulte ou d'un poisson de grande taille (> 400 mm) pendant le passage à travers des turbines à hélices de grande taille (groupe kaplan ou groupe bulbe). Les données de survie directe pour les anguilles adultes traversant des turbines présentant des caractéristiques similaires à celles de la turbine-bulbe de Beaucaire sont notamment limitées pour permettre une comparaison directe avec les résultats ci-dessous. Avant l'étude de Beaucaire, des estimations de survie directe obtenue par la méthode de recapture avec étiquettes HI-Z n'étaient fournies que par la centrale Robert Moses sur le Saint Laurent, dans l'état de New York (Normandeau Associates and Skalski 1998) et la centrale de Fessenheim (EDF) sur le Rhin en France (Normandeau Associates 2010). La turbine testée à la centrale Robert Moses était une unité à hélices à pales fixes avec 6 pales, un diamètre de 6,1 m, une vitesse de rotation de 95 t/min et une hauteur de chute de 25 m. Les caractéristiques des turbines de Fessenheim étaient de 4 pales, d'un diamètre de 6,67 m, d'une vitesse de rotation de 88,2 t/min et d'une hauteur de chute de 15,3 m.

Les anguilles testées à la centrale Robert Moses étaient plus grosses (longueur moyenne 1020 mm) qu'à Fessenheim (longueur moyenne 704 mm). La taille des anguilles testées à Beaucaire (686 mm) était similaire à celles de Fessenheim. La survie directe rapportée à 1 h et 88 h après le passage pour l'étude de la centrale Robert Moses était respectivement de 84% et de 75%. Les taux de survie à 48 h après le passage n'ont pas été transmis. Les taux de survie à 1 h et 48 h pour Fessenheim étaient respectivement de 93,2% et 92,4%. Des poissons plus gros, des pales plus nombreuses (6 au lieu de 4) et une plus grande hauteur de chute ont vraisemblablement compté pour beaucoup dans le taux de survie inférieur constaté à la centrale Robert Moses par rapport à celui obtenu à Fessenheim et à Beaucaire.

Le taux de survie directe des anguilles étiquetées H—Z après le passage des turbines de Fessenheim et de Beaucaire était supérieur à celui constaté sur de gros poissons de fond étiquetés HI-Z après leur passage dans plusieurs autres turbines à hélices. La survie directe à 48 h d'une autre espèce, «le doré jaune » adulte (*Sander vitreus*) d'une longueur moyenne d'environ 450 mm était de 80,4% et de 87,8% après son passage dans une turbine à hélice à 6 pales et à 6 pales à la centrale de Kelsey

au nord du Manitoba, au Canada (North/South Consultants and Normandeau Associates 2009). Les turbines de la centrale de Kelsey avaient un diamètre de pales de 7,9 m, une vitesse de 103 tr/min et une hauteur de chute de 17 m. Le grand brochet (Esox lucius), d'une longueur moyenne d'environ 600 mm, après passage à travers ces deux turbines de Kelsey équipées de 5 ou 6 pales avait des taux de survie à 48 h inférieurs, respectivement de 65,8 et 75,5%.

Selon le modèle de turbine et les données hydrauliques, la situation est en général pire pour les poissons qui passent à l'extrémité de la pale que pour ceux qui sont plus proches du moyeu, sauf si les espaces entre le moyeu et les pales sont importants. Les anguilles relâchées à travers la turbine de Beaucaire auraient dû passer près de l'extrémité et du milieu de la pale. Les taux de survie et d'absence de maladie pour les deux points de passage étaient similaires à Beaucaire et n'ont pas suivi la tendance qui voulait que les taux de mortalité ou de blessures soient plus élevés à l'extrémité de la pale.

5. CONCLUSIONS

L'objectif de l'étude d'estimation du taux de survie de l'anguille européenne adulte (570 mm à 1070 mm) au passage de la turbine du groupe n°3 a été atteint. La combinaison des taux de recapture relativement élevés (95,6%) et du taux de survie des anguilles témoins élevé (100%) a permis d'obtenir des estimations de survie et de blessures directes valables et relativement précises. La survie directe des anguilles adultes après passage à travers les turbines bulbes de Beaucaire pendant des opérations types devrait approcher 92% et le taux de blessure devrait approcher 8%. A ce jour, les turbines bulbes de Beaucaire semblent être moins dangereuses pour les gros poissons que la plupart des autres turbines de type Kaplan/à hélices selon la technique de recapture directe avec étiquetage HI-Z.

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TABLEAUX, FIGURES ET ANNEXES

Se reporter au rapport original Normandeau

RAPPORT ORIGINAL NORMANDEAU

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Final

APRIL 2011

FINAL REPORT

DIRECT SURVIVAL/INJURY OF EELS PASSING THROUGH BEAUCAIRE STATION, RHONE RIVER, FRANCE

Prepared for

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EXECUTIVE SUMMARY

Survival probabilities (1 and 48 hr) of adult European eels, *Anguilla anguilla*, were estimated upon passage through a 4 bladed bulb turbine at Beaucaire Station on the Rhone River in France. The eels ranged in size from 570 mm to 1040 mm with an average size of 686 mm. The study utilized the HI-Z Turb'N tag-recapture technique (HI-Z tag) and was initiated on 6 September and completed on 15 September 2010 at water temperatures ranging from 19.0°C to 23.5°C. A total of 275 eels were introduced into Unit 3 at two release depths (0.5 m below the intake ceiling, tip and 3.5 m below the intake ceiling, mid) while 50 eels were released into the discharge as controls. Tip and mid released fish were projected to pass near the turbine blade tip and mid blade, respectively.

Recapture rates (physical retrieval of live and dead eels) were high for both tip and mid releases, 96.4 and 95.1% respectively. Most specimens were recaptured within 10 minutes after release. The combination of high recapture rates and high control survival (100%) provided a statistically valid survival estimate for adult eels passing through a hydroelectric turbine at the Beaucaire Station in France.

The 1 h direct survival was 95.5% (tip) and 95.7% (mid) with a pooled value of 95.6%. Survival at 48 h was 93.7 and 91.4% for tip and mid releases, respectively; pooled value was 92.3%. The precision of the survival estimates (1 and 48 h) for the tip and mid releases were all ± 4%, 90% of the time and the precision of the pooled estimates were ± 3%, 90% of the time. The target precision of ± 5%, 90% of the time for each passage location was attained.

Malady-free rates (free of visible injuries and loss of equilibrium) of the adult European eels passed through the Beaucaire Station were relatively high for tip and mid releases. Mid released eels had a malady-free rate of 92.3%, followed by 90.7% for the tip released eels. The pooled malady-free rate for both releases was 91.6%.

The primary injury was bruising on head and body and was attributed to mechanical causes resulting from blade strikes or direct contact with other structural components during turbine passage. The direct survival and malady-free rates at the Beaucaire turbine were similar to those obtained for similar sized adult eels passed through a 4 bladed Kaplan turbine at the Fessenheim Station. The bulb turbines at Beaucaire appear to be friendlier to large fish than most other Kaplan/propeller type turbines evaluated by the HI-Z tag direct recapture technique to date.

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1.0 INTRODUCTION

There are two primary components of total mortalility of fish/eels entrained in hydro turbines: direct and indirect effects. The direct effects (e.g., mechanically- induced, pressure, cavitation, or shear related) are manifested immediately after turbine passage as instantaneous fish mortality, injury, and loss of equilibrium; the indirect effects (e.g., predation, disease, physiological stress, etc.) may occur over an extended period or distance downstream after passage. Compagnie Nationale du Rhone, (CNR) was interested in obtaining estimates of direct effects of turbine passage on Adult European eels (*Anguilla anguilla*) at the Beaucaire Power Station.

1.1 Project Description

The Beaucaire Power Station (Figure 1-1) is located on the Rhone River in the south of France just north of Arles and Marseille at latitude 43.824N and longitude 4.644E. Operational since 1970**,** Vallabregues is the last power station on the Rhone before entering the Mediterranean Sea. This facility contains three aspects: the dam of Vallabregues, the hydroelectric power plant and the lock of Beaucaire. The Beaucaire Station is equipped with 6 Bulb turbine units. Each turbine has four blades that rotate at 94 rpm, operational head near 14 m, and runner diameter of 6.24 m (Table 1-1). Beaucaire Power Station produces 210 MW of hydro electricity, with an annual production averaging 1.3 billion kWh. This corresponds approximately to the annual power consumption of the city of Nice. The lock dimensions are 190 m long, and 12 m wide, with a 16 m rise and fall. Heavily influenced by the Roman Empire, Beaucaire is located within the region of Languedoc-Roussillon. The town is at the eastern edge of the Gard department, to the east of Nimes. Closely linked to Tarascon which is found just across the Rhone River from Beaucaire (in the Provence region), Beaucaire is rich with history, culture, and fine cuisine.

2.0 STUDY DESIGN

2.1 Objectives

The primary objectives of the study were to estimate the direct (1 and 48 h) survival and malady-free rates (eels without visible injuries and no loss of equilibrium) of adult European eels (Anguilla anguilla) passing at two different locations through Unit 3 turbine at the Beaucaire Station using the HI-Z Turb'N tag (HI-Z) fish recapture technique (Heisey *et al*. 1992). Eels were released so their projected path was near the blade tip (tip) or near mid blade (mid). Eels were released 0.5 m below the intake ceiling to direct eels toward the blade tip and 3.5 m below the ceiling to direct eels toward mid blade (Figures 2-1 and 2-2). After passage, live and dead eels were enumerated and each eel was examined for injuries. Survival and malady-free rates were estimated for each passage location and combined locations. Descriptions of the observed injuries were recorded to help assess the probable causal mechanisms for injury/mortality which may in turn be used to identify potential mitigative measures.

2.2 Operational Conditions

The operational and physical parameters measured during the release of eels through Unit 3 are presented in Table 2-1. Discharge through Unit 3 averaged 313 m^3/s at Beaucaire Dam. The power output was near 35 MW for Unit 3 and operational head near 14 m. Total discharge through the Beaucaire station was near 1200 m^3/s during the study. Turbine Unit 3 was tested near the settings the unit is operating at most of the time to evaluate typical conditions.

2.3 Sample Size Calculations

Prior to initiating the study, the sample size requirement had been determined to fulfill the primary objective of obtaining survival and malady-free estimates within a pre-specified precision (ε) level. The sample size is a function of the recapture rate (P_A), expected passage survival ($\hat{\tau}$) or mortality (1-$\hat{\tau}$), survival of control eels (S), and the desired precision (ε) at a given probability of significance (α). In general, sample size requirements decrease with an increase in control eels surviving, being malady-free and recapture rates (Mathur *et al*. 1996, 2000 and Table 2-2). Only precision and α level can be strictly controlled by an investigator. Results of a previous turbine direct survival study on eels indicate a sample size of approximately 350 (300 treatment and 50 control) eels should be sufficient to attain survival estimates ± 0.05, 90% of the time, for the selected operating condition. This number assumes close to 100% control survival, a recapture rate of 95% and expected passage survival and malady-free rates of > 85% for a specific study. With similar control survival, recaptures rates, and passage survival, the precision of ± 0.10, 90% of the time on the survival estimates should be attainable for each of the two passage locations (tip and mid). A total of 275 treatment eels were released within the turbine intake and 50 control eels were released into the tailrace during the study (Table 2-3).

2.4 Source and Maintenance of Specimens

Eels for this study were obtained by a local fisherman with a multi chambered fyke net from the Rhone River near Arles, approximately 30 km downstream of Beaucaire, and Caderousse, approximately 45 km upstream of Beaucaire Dam. Fish were transported in a fish hauler, and delivered to one of two holding pools located on the tailrace (Figures 2-3 and 2-4). These holding pools held an estimated 2000 L of water. All pools were housed in a covered area near the control room. Only eels in good physical condition were used for this study.

Ambient river water was continually supplied (2 m^3/h) to each pool and all fish were held for a minimum of 12-24 h prior to tagging which allowed fish time to recover from initial capture and handling stress. Water temperatures in the holding pools were comparable with river temperatures, which ranged from 20.8 to 23.0ºC.

The 275 treatment eels released ranged in size from 580 mm to 1040 mm, with the average size of 686 mm (Figure 2-5). The 50 control eels releases ranged in size from 590 mm to 900 mm, with an average size of 697 mm. The average size of test, and control eels combined was 690.5 mm.

2.5 Tagging and Release

In order to bring large eels to the surface for rapid recapture, four to six HI-Z balloon tags were attached with a small cable tie through the musculature at two or three locations along the eel's back via a curved cannula needle (Figures 2-6 and 2-7). Radio tags were attached in combination with one of the HI-Z tags to aid in tracking released eels. Specially designed eel restraint devices developed and built by Normandeau aided in tagging test eels (Figure 2-8).

In addition to the restraining device, the eels were subdued during tag attachment with an electro-anesthetic unit. The electro-anesthetic unit (EAU) used on this study was an Endomorph EA-60 manufactured by Marine Electrics (Ireland) Ltd., Killybegs, County Donegal, Ireland. The EAU consisted of two rectangular stainless steel plates (anode and cathode) wired to a control box and powered by a 12 volt, 7 amp motorcycle battery. Eels were aligned perpendicular to the electrode

plates with their heads and tails toward the anode and cathode, respectively, prior to current application.

Eels were individually marked and identified with small numbered floy tags. The tubular floy tags were inserted into musculature near the anterior region of the dorsal fin. Just prior to release, the HI-Z tags were activated by injecting a small amount of water into the HI-Z tag, which causes the tag to inflate in approximately 2 to 4 minutes. Tags were activated while the eel was still in the restraining device and fish released (Figures 2-9 to 2-11).

All eels were released through borrowed induction systems constructed by EDF from Normandeau plans (Figure 2-12). The induction apparatus was connected to 10.2 cm diameter hoses which allowed the eels to pass freely to the desired release points for both treatment and control fish. The treatment eel release hoses were secured to a steel lifting beam which was lowered into the intake gate slot (Figure 2-13). The beam with two release hoses attached was lowered to a point where the end of the one hose was 0.5 m below the intake ceiling and the other hose was 3.5 m below the intake ceiling. The lifting beam was kept just above the intake ceiling and out of the flow passing toward the turbine (Figure 2-2). These release locations were projected to take the eels near the turbine blade tip and mid blade respectively, if the eels follow the in-turbine flow. Each release hose had a continuous supply of river water to ensure eels were transported quickly to the desired release point. Control eels were released through an identical induction apparatus attached to a 10.2 cm diameter flexible hose that released fish into the tailrace downstream of the powerhouse (Figure 2-3).

Procedures for handling, tagging, release and recapture of eels were similar for treatment and control groups. Eels were randomly selected from the holding pools located on the intake deck using dip nets.

2.6 Eel Recapture Methods

After release (either as treatment or control), the eels were tracked and then retrieved when buoyed to the surface downstream of the Beaucaire Station by one of three recapture boat crews (Figure 2-14). Boat crews were notified of the radio tag frequency of each eel upon its release. Radio signals were received on a 5-element Yagi antenna or Loop antenna coupled to an Advanced Telemetry System receiver (Figure 2-15). The radio signal transmission (48 or 49 MHz) enabled the boat crews to follow the movement of each eel after passage and position the boats downstream for retrieval when eels were buoyed to the surface (Figures 2-16 to 2-18). Eels that surfaced at the downstream face of the station and failed to move downstream were captured by a drop net deployed from the tailrace deck.

Recaptured fish were placed into an on-board holding facility (Figure 2-19) and all tags were removed with the exception of the floy tag. Each eel was immediately examined for maladies consisting of visible injuries, loss of equilibrium (LOE), and assigned appropriate condition codes (Table 2-4). Tagging and data recording personnel were notified via a two-way radio system of each eel's recapture time and condition.

Recaptured eels were transported to shore and held in holding pools (2000 L) to monitor delayed (48 h) effects of tagging and turbine passage. Pools were continuously supplied with ambient river water (2 m^3/h) and shielded to prevent potential eel escape or predation. Eels that were alive at 48 h and free of major injuries were released into the river.

2.7 Assessment of Fish Injuries

All recaptured eels, dead or alive, were examined for types and extent of external injuries (Figures 2-20 to 2-23). Dead eels were also necropsied for internal injuries when there were no apparent external injuries. Injuries were categorized by type, extent, and area of body. Eels without visible injuries that were not actively swimming or swimming erratically at recapture were classified as having "loss of equilibrium". This condition has been noted in most past HI-Z tag direct survival/injury studies and often disappears within 10 to 15 min after recapture if the fish is not injured. Visible injuries and LOE were categorized as minor or major. The criteria for this determination are based primarily on Normandeau personnel field observations (Table 2-5).

A malady classification was established to include eels with visible injuries, bruising (≥ 20% on either side), or LOE. Eels without maladies were designated "malady-free". The malady-free metric is established to provide a standard way to depict a specific passage route's effects on the condition of entrained fish (Normandeau Associates and Skalski 2006). The malady-free metric is based solely on fish physically recaptured and examined. Additionally, the malady-free metric in concert with site-specific hydraulic and physical data may provide insight into what passage conditions and locations present safer fish passage.

2.8 Classification of Recaptured Fish

As in previous investigations (Mathur *et al*. 1996, 2000 Normandeau Associates 2010; Normandeau and Skalski 1998 and 2006; North/South Consultants Inc. and Normandeau Associates Inc. 2007, 2009) the immediate post-passage status of an individual recaptured eel and recovery of inflated tags dislodged from eel were designated as alive, dead, or unknown. The following criteria have been established to make these designations: (1) alive—recaptured alive and remaining so for 1 h; (2) alive—fish does not surface but radio signals indicate movement patterns; (3) dead—recaptured dead or dead within 1 h of release; (4) dead—only inflated dislodged tag(s) are recovered, and or telemetric tracking or the manner in which inflated tags surfaced is not indicative of a live fish; and (5) unknown—no fish or dislodged tags are recaptured, or radio signals are received only briefly, and the subsequent status cannot be ascertained. Eels that moved into areas where they could not be recaptured (i.e. rip rap along shore, submerged crevices, and areas of high turbulence) were not included in the statistical analysis. During the present study only two eels moved into an area where they could not be safely recaptured.

Mortalities of recaptured eels occurring after 1 h were assigned 48 h post-passage effects although eels were observed at approximately 12 h intervals. Dead eels were examined for bruising and injury, and those that died without obvious injuries were necropsied to determine the probable cause of death. Additionally, all specimens alive at 48 h were closely examined for injury. The initial examination allowed detection of some injuries, such as bleeding and minor bruising that may not be evident after 48 h due to natural healing processes.

2.9 Survival and Malady-Free Estimation

Separate survival probabilities (1 and 48 h), malady-free estimates, and their associated standard errors were estimated using the likelihood model given in Mathur *et al*. (1996) and Normandeau Associates Inc. and Skalski 1998. The formulas follow:

Direct Survival, 1 and 48 hours

Where:

$$\hat{\tau}_i = \frac{a_{Ti} R_c}{R_{Ti} a_c},$$

R_{Ti} = Number of fish released for the treatment condition (i = 1,..., 9);

a_{Ti} = Number of fish alive for the treatment condition (i = 1,...,9);

R_c = Number of control fish released;

a_c = Number of control fish alive;

Malady-Free (MF) Fish

Where:

$$MF_i = \frac{c_{Ti} R_c}{R_{Ti} c_c},$$

C_{Ti} = Total number of fish without maladies for treatment i (i = 1,...,9);

R_{Ti} = Number of fish recovered that were examined for maladies for treatment i (i = 1,...,9);

C_c = Number of control fish recovered without maladies;

R_c = Number of control fish recovered that were examined for maladies.

A t-test was run to determine if survival and/or injury is related to passage location or eel length. Significance was assigned at $P \leq 0.10$ for all statistical tests.

2.10 Assignment of Probable Sources of Injury

Limited controlled experiments (Neitzel *et al*. 2000; Pacific Northwest National Laboratory et al. 2001) to replicate and correlate each injury type/characteristic to a specific causative mechanism provides some indication of the cause of observed injuries in the field. Some injury symptoms can be manifested by two different sources that may lessen the probability of accurate delineation of a cause and effect relationship (Eicher Associates 1987). Only probable causal mechanisms of injury were assigned for the present investigation.

Some injuries (e.g., sliced bodies) may be assigned to a specific causative source with greater certainty (Normandeau Associates *et al*. 1995). Injuries likely to be associated with direct contact of turbine runner blades or structural components are classified as mechanical and include: bruise, laceration, and severance of the fish body (Dadswell *et al*. 1986; Eicher Associates 1987; RMC and Skalski 1994a, b). Passage through gaps between the runner blades and the hub or at the distal end may result in pinched bodies (Normandeau Associates *et al*. 1995). Contact with the turbine structural components may result in bruising. Injuries likely to be attributed to shear forces are decapitation, torn or flared opercula, and hemorrhaged eyes (Dadswell *et al*. 1986). The probable pressure-related effects are manifested as hemorrhaged internal organs; however, pressure related forces can also cause bulging and hemorrhaged eyes. Detailed information on station operations are presented in Appendix A; detailed tag-recapture data is presented in

Appendix B; statistical analysis in Appendix C; individual fish data in Appendix D; and fish injury photos in Appendix E.

3.0 RESULTS

3.1 Recapture Rates

The HI-Z tag recapture technique performed satisfactory with generally high recapture rates (physical retrieval of live and dead eels). Adult European eels were passed through Turbine Unit 3 operating at approximately 35 MW and discharging approximately 300 m³/s at Beaucaire Station (Table 2-1). Controls were released into the tailrace downstream of the power house. Eels were released on seven days between the 6 and 13th of September, 2010 and releases were primarily concentrated on the tip, or mid locations on a given day (Table 2-3). Recapture rate was high at 94.9 and 100% of the treatment and control eels, respectively (Table 3-1). Only inflated HI-Z tags were recaptured on 10 (3.6%) treatment eels and nothing was recaptured on 2 (0.7%) treatment eels. The eels with only the HI-Z tags recaptured were assigned a dead status and those with nothing recaptured were classified as unknowns.

3.2 Recapture Times

Recapture times (the time interval between eel release and subsequent recapture) for the two treatment groups, tip and mid at Beaucaire Power Station was 4.2, and 5.8 minutes respectively (Figure 3-1). The average time for control recaptured was 7.7 minutes. The longest time before recapture was 197 minutes for an eel passed near mid blade.

3.3 Survival Estimates

The 1 h direct survival ranged from 95.5 % (tip) to 95.7% (mid) with a pooled value of 95.6% (Table 3-1). Survival at 48 h was 93.7 and 91.4% for the tip and mid releases, respectively; pooled value was 92.3%. This estimate included fish still alive at 48 h but that were considered functionally dead (severely injured). The precision of the survival estimates (1 and 48 h) for the tip and mid releases were all ±3.8 and 3.6%, respectively, 90% of the time. The precision of the pooled estimates was ± 2.6%, 90% of the time. The target precision of ± 10.0%, 90% of the time for each passage location survival estimates was attained as well as the target for the pooled estimates of ± 5%, 90% of the time. Survival estimates for the tip and mid passed fish were not significantly different ($P > 0.10$).

3.4 Injury Rate, Types, and probable Source

Overall, 263 of 275 treatment eels were recaptured and examined for injuries (Table 3-2). A total of 18 (6.8%) of the eels had visible injuries and another 4 (1.5%) displayed only loss of equilibrium. Of the 112 eels released that passed near the blade tip, 108 (96.4%) were examined, eight (7.4%) of these showed visible signs of passage related injuries. Two (1.9%) displayed only loss of equilibrium. Injury rates were similar for mid passed eels. Of the 163 eels released from the mid depth, 155 (95.1%) were examined and 10 (6.5%) showed visible signs of passage related injuries; 2 additional fish had only loss of equilibrium.

The primary injury observed on tip passed eels was bruising on the head and along the body (4.6%, Tables 3-3 and 3-4 and Figures 20 to 23). Two eels were severed (1.9%) one eel had bleeding from the gills and another had a broken backbone. Injury types of mid passed eels were

similar to those for the tip passed eels. Seven (4.5%) of the recaptured mid passed eels were bruised along the head or the body, four (2.6%) were bleeding from the gills, two (1.3%) had internal hemorrhage or broken back bones, and one (<1%) was severely cut. All of the 50 control eels released were examined and none were injured.

Mechanical forces were attributed to nearly all (18 of 22) observed injuries on the turbine passed eels; cause could not be determined for four eels (Tables 3-4, 3-5). The mechanical injuries were likely caused by blade strike or contact with other structures within the flow path. Most (17 of 22) of the maladies inflicted during turbine passage were classified as being major and resulted in death or were considered life threatening.

3.5 Malady-Free Estimates

Malady-free estimates (i.e., fish free of passage-related maladies) are presented on (Table 3-2). Malady-free estimates rates were adjusted by any maladies incurred by control. The malady-free estimates for tip released adult eels were 90.7% with a 90% CI of ± 4.6%. The malady-free estimates for mid released eels were 92.3% with a 90% CI of ± 3.5%. The pooled malady-free estimates for both tip, and mid release was 91.6% with a 90% CI of ± 2.8%. The desired precision (± 5%, 90% of the time) on the malady-free estimates was met. Malady-free estimates for the tip and mid passed fish were not significantly different ($P > 0.10$).

3.6 Size Effect on Survival and Injury

The effect of eel length on survival and malady-free rates were examined (Figures 3-2 and 3-3). There was no indication that the larger fish had lower survival or malady-free rates. This may be due to the low number of dead and injured fish and the limited size range of tested specimens.

4.0 PRINCIPLE FINDINGS AND DISCUSSION

The primary objectives of the study of determining direct survival and injury of adult eels passed through a turbine at the Beaucaire Station were achieved. The turbine passage survival/injury estimates can be considered valid with fulfillment of some underlying assumptions and the use of an appropriate model to fit the data (Burnham *et al*. 1987; Mathur *et al.* 1996). The following assumptions, primarily related to the tag-recaptured process, were fulfilled: handling, tagging, and release procedures did not differentially affect the survival rates of control and treatment groups; and both the treatment and control groups were exposed to similar tailrace conditions. Additionally the HI-Z tags didn't inflate until after turbine passage and were neutrally buoyant until inflated. The HI-Z tagged eels should have had the same opportunity as untagged emigrating eels to be exposed to mechanical, shear, and turbulent forces during turbine passage. A potential source of bias due to non-selected retrieval of treatment and control groups was minimized by not assigning a specific boat recovery crew to recapture either treatment or control fish.

A total of 175 treatment eels were released within the turbine intake and 50 control eels were released into the tailrace during the study. The 175 treatment eels released ranged in size from 580 mm to 1040 mm, with the average size of 686 mm. The 50 control eels releases ranged in size from 590 mm to 900 mm, with an average size of 697 mm.

The combination of a relatively high treatment recapture rate (95.6%) and 100% control survival provided valid and relatively precise survival and injury estimates. The 1 h direct survival

estimates for adult eels passed through the Unit 3 turbine was 95.5 and 95.7% for tip and mid passed fish respectively. The corresponding 48 h estimates were 93.7% and 91.4% with combined estimates of 92.3%.

Overall, 18 of the 275 (6.8%) recaptured treatment fish displayed visible injuries. The most common injury was bruising to the head and body. Most (77%) of the turbine inflicted injuries were lethal or life threatening. The majority of the injuries appeared to be due to mechanical forces associated with blade strike and or contact with other structures in the flow path. The malady-free estimates for the tip and mid passed fish were relatively high (90.7 and 92.3%, respectively) and the overall estimate was 91.6%.

There are three primary risks associated with turbine passage: (1) mechanical damage due to direct contact with rotating runner blades or structural components or passage through gaps; (2) rapid change in water pressure relative to fish's acclimation pressure history; and (3) hydraulic shear forces or cavitation. These risks, however, are not universally applicable to all species and their life stages or at all turbines. Differential proportion of entrained fish may be exposed to any of these risks at a site. (Heisey *et al*. 1992; Mathur *et al*. 1996; Normandeau Associates *et al*. 1995). Mechanically-related injuries are primary a function of the number of runner blades, rotation rate, and fish size relative to turbine runner diameter size.

Little information exists on survival rates of adult eel or large sized fish (>400 mm) in passage through relatively large Kaplan and propeller type turbines such as at Beaucaire. In particular, direct survival data for adult eels passing through turbines with characteristics similar to the bulb turbine of Beaucaire are limited to provide a direct comparison to the results herein. Previous to the Beaucaire study direct survival estimates obtained by the HI-Z tag recapture method were available from only the Robert Moses station on the St. Lawrence River, New York (Normandeau Associates and Skalski. 1998) and the Fessenheim Station on the Rhine River in France (Normandeau Associates, 2010). The turbine tested at Robert Moses was a fixed blade propeller unit with 6 blades, runner diameter of 6.1 m, rotational speed of 95 rpm, and operational head of 25 m. The characteristics of the Fessenheim turbines were 4 blades, 6.67 m runner diameter, 88.2 rpm, and 15.3 head.

The sizes of eels tested at the Robert Moses station were larger (average length 1020 mm.) than at Fessenheim (average length 704 mm). The size of the eels tested at Beaucaire (686 mm) was similar to those at Fessenheim. Direct survival reported for 1 h and 88 h post passage for the Robert Moses study was 84 and 75% respectively. Forty-eight (48 h) post passage survival rates were not reported. The 1 h and 48 h survival reported for Fessenheim were 93.2 and 92.4% respectively. The larger fish, more blades (6 verses 4), and higher head likely accounted for much of the lower survival rate at the Robert Moses station than obtained at Fessenheim and Beaucaire.

The direct survival of the HI-Z tagged eels passed through both Fessenheim and Beaucaire turbines was higher than that reported for other large, deep bodied HI-Z tagged fish passed through several other propeller type turbines. The 48 h direct survival of adult walleye (*Sander vitreus*) with a mean length near 450 mm was 80.4 and 87.8% upon passage through a 6 bladed and 5 bladed propeller turbine at the Kelsey generating station in northern Manitoba, Canada (North/South Consultants and Normandeau Associates 2009). The turbines at the Kelsey station had a runner diameter of 7.9 m, rotated at 103 rpm and operated at approximately 17 m head. Large northern pike (Esox lucius), with a mean length of approximately 600 mm that were also passed through the 6 and 5 bladed Kelsey turbines had lower 48 h survival rates of 65.8 and 75.5% respectively.

Based on the turbine design and hydraulic data, fish that pass towards the blade tip generally fare worse than those closer towards the hub, unless there are large gaps at the blade-hub interface. The eels released through the Beaucaire turbine should have passed close to the tip and mid blade. The survival and malady-free rates for the two passage locations were not significantly different (P>0.10) at Beaucaire and did not follow the trend for higher mortality/injury at the blade tip.

The thickness of the blades, particularly the leading edge can also affect the survival and injury rate of turbine passed fish. The maximum blade width was 70 mm near the tip, 110 mm near mid blade and 200 mm near hub (Figure 4-1). The leading edge of each blade was rounded along its entire length; however it was quite narrow toward the tip; approximately 40 mm in width at 300 mm behind the leading edge. Although the leading edge near the blade tip was quite narrow, the malady-free rate was only slightly less (90.7% tip versus 92.3% mid). The profile and thickness of the leading edge of the turbine blades did affect the condition of large fish passed through two fixed propeller turbines at the Kelsey Station in Canada (North/South Consultants, Inc. and Normandeau Associates, Inc. 2009). The malady-free rate of large northern pike (average length 600 mm) was 45.2% upon passing a 6 bladed turbine but decreased to only 37.6% after passing a 5 bladed turbine. The one less blade should have inflicted fewer injuries; however examination of the shape and thickness of the leading edge of the turbine blades revealed that the leading edges of the blades were much narrower on the turbine unit that inflicted the higher injury rate.

5.0 CONCLUSIONS

The objective of the study of estimating survival rate of adult European eel (570 mm to 1070 mm) in passage through turbine Unit 3 was fulfilled. A combination of relatively high recapture rates (95.6%) and high control survival (100%) provided valid and relatively precise direct survival and injury estimates. Based on the Unit 3 results, the direct survival of adult eels passed through the remaining Beaucaire bulb turbines at typical operations should be close to 92%; injury rate close to 8%. The bulb turbines at Beaucaire appear to be friendlier to large fish than most of the other Kaplan/propeller type turbines evaluated by the HI-Z tag direct recapture technique to date.

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TABLES

Table 1-1

Physical and hydraulic characteristics of a propeller type turbine at Beaucaire Dam, France.

	Existing (Unit 3)
Type:	Bulb
Rated Output (MW):	210
MW Unit 3 during at test:	35
Approximate flow (cms) at rated output:	366
Approximate flow (cms) at test:	313
No. of blades	4
Blade thickness: Hub	70 mm
Mid	110 mm
Tip	200 mm
RPM of blades:	93.8
Runner diameter:	6.24 m
Water passage diameter:	6.25 m
Blade tip speed (m/s):	30.6
No. of wicket gates:	4
Typical operational head (m):	13.5
Maximum head (m):	15

Table 2-1

Physical parameters (mean values for each scenario) measured during the release of adult European eels passed through Turbine Unit 3 near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge.

		Elevations			Turbines	
Turbine Unit 3 Release Depth	**Power Product (MW)**	**Upstream Water Level (mNN)**	**Downstream Water Level**	**Head (m) Estimation**	**Turbine Unit 3 Discharge (m^3/s)**	**Total Station Discharge (m^3/s)**
Tip	35.7	15.6	2.0	13.6	316	1212
Mid	35.2	15.7	2.0	13.7	310.1	1183.1
Combined	35.5	15.7	2.0	13.7	313.1	1197.6
			Controls			
	35.9	15.7	2.2	13.4	323	1209

Table 2-2

Required sample sizes for treatment and control fish releases for various combinations of control survival (S), recapture probability (P_A), and expected turbine passage ($\hat{\tau}$) to obtain a precision (ε) of ± 0.10 or ± 0.05, 90% of the time.[1]

Control Survival (S)	Recapture Rate (P_A)	Expected Survival ($\hat{\tau}$)	Number of Fish at (ε) 0.10	0.05
1.00	0.99	0.95	18	72
		0.90	29	116
		0.85	39	155
	0.95	0.95	39	157
		0.90	49	195
		0.85	57	228
	0.90	0.95	69	274
		0.90	76	303
		0.85	82	327
0.95	0.99	0.95	45	178
		0.90	54	215
		0.85	61	246
	0.95	0.95	67	268
		0.90	74	297
		0.85	80	322
	0.90	0.95	98	391
		0.90	103	411
		0.85	107	427

[1]Table values also applicable for malady-free estimates.

Table 2-3

Daily schedule for adult European eels, passed through Turbine Unit 3, near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge.

			Control
Passage location	**Tip**	**Mid**	**Downstream**
Date			
6-Sep	5	5	5
7-Sep	45		1
8-Sep*		17	2
9-Sep		30	20
10-Sep	62		7
11-Sep		65	10
12-Sep	delayed assessment		
13-Sep		46	5
14-Sep	delayed assessment		
15-Sep	delayed assessment		
Total	**112**	**163**	**50****

*High flow event delayed testing.

**Two additional control fish removed from sample due to unrecoverable conditions

Table 2-4

Condition codes assigned to fish and dislodged HI-Z tags for fish passage survival studies.

Status Codes	Description
*	Turbine/passage-related malady
4	Damaged gill(s): hemorrhaged, torn or inverted
5	Major scale loss, >20%
6	Severed body or nearly severed
7	Decapitated or nearly decapitated
8	Damaged eye: hemorrhaged, bulged, ruptured or missing, blown pupil
9	Damaged operculum: torn, bent, inverted, bruised, abraded
A	No visible marks on fish
B	Flesh tear at tag site(s)
C	Minor scale loss, <20%
E	Laceration(s): tear(s) on body or head (not severed)
F	Torn isthmus
G	Hemorrhaged, bruised head or body
H	LOE
J	Major
K	Failed to enter system
L	Fish likely preyed on (telemetry, circumstances relative to recapture)
M	Minor
P	Predator marks
Q	Other information
S	Eel study only - Functionally dead
R	Removed from sample
T	Trapped in the rocks/recovered from shore
V	Fins displaced, or hemorrhaged (ripped, torn, or pulled) from origin
W	Abrasion / Scrape

Survival Codes	
1	Recovered alive
2	Recovered dead
3	Unrecovered – tag & pin only
4	Unrecovered – no information or brief radio telemetry signal
5	Unrecovered – trackable radio telemetry signal or other information

Dissection Codes			
1	Shear	M	Minor
2	Mechanical	N	Heart damage, rupture, hemorrhaged
3	Pressure	O	Liver damage, rupture, hemorrhaged
4	Undetermined	R	Necropsied, no obvious injuries
5	Mechanical/Shear	S	Necropsied, internal injuries
6	Mechanical/Pressure	T	Tagging/Release
7	Shear/Pressure	W	Head removed; i.e., otolith
B	Swim bladder ruptured or expanded		
D	Kidneys damaged (hemorrhaged)		
E	Broken bones obvious		
F	Hemorrhaged internally		
J	Major		
L	Organ displacement		

Table 2-5

Guidelines for major and minor injury classifications for fish passage survival studies using the HI-Z Tags.

1	A fish with only LOE is classified as major if the fish dies within 1 hour. If it survives or dies beyond 1 hour it is classified as minor.
2	A fish with no visible external or internal maladies is classified as a passage related major injury if the fish dies within 1 hour. If it dies beyond 1 hour it is classified as a non passage related minor injury.
3	Any minor injury that leads to death within 1 hour is classified as a major injury. If it lives or dies after 1 hour it remains a minor injury.
4	Hemorrhaged eye: minor if less than 50%. Major if 50% or more.
5	Deformed pupil(s) are a: major injury.
6	Bulged eye: major unless one eye is only slightly bulged. Minor if slight.
7	Bruises are size-dependent. Major if 10% or more of fish body per side. Otherwise minor.
8	Operculum tear at dorsal insertion is: major if it is 5 % of the fish or greater. Otherwise minor.
9	Operculum folded under or torn off is a major injury.
10	Scale loss: major if 20% or more of fish per side. Otherwise minor.
11	Scraping (damage to epidermis): major if 10% or more per side of fish. Otherwise minor.
12	Cuts and lacerations are generally classified as major injuries. Small flaps of skin or skinned up snouts are: minor.
13	Internal hemorrhage or rupture of kidney, heart or other internal organs that results in death at 1 to 48 hours is a major injury.
14	Multiple injuries: use the worst injury

Table 3-1

Summary tag-recapture data for adult European eels, passed through Turbine Unit 3, near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge. Proportions are given in parentheses.

	Turbine Unit 3			Combine
	Tip	Mid	Combined	Controls
Number released	112	163	275	50
Number recaptured alive	106 (0.946)	155 (0.951)	261 (0.949)	50 (1.000)
Number recaptured dead	2 (0.018)	0 (0.000)	2 (0.007)	0 (0.000)
Number assigned dead*	3 (0.027)	7 (0.043)	10 (0.036)	0 (0.000)
Dislodged tags	3 (0.027)	7 (0.043)	10 (0.036)	0 (0.000)
Stationary radio signals	0 (0.000)	0 (0.000)	0 (0.000)	0 (0.000)
Number undetermined	1 (0.009)	1 (0.006)	2 (0.007)	0 (0.000)
Number held	106	155	261	50
1 hour survival rate	0.955	0.957	0.956	
SE	0.020	0.016	0.012	
90% CI (+/-)	0.033	0.026	0.020	
Number alive 48 hour	105	149	254	50
Number died in holding	1	6	7	0
48 hour survival rate	0.946	0.920	0.930	
SE	0.018	0.021	0.015	
90% CI (+/-)	0.029	0.035	0.025	
Number dead and functionally dead**	2	7	9	0
48 hour survival (including functionally dead)	0.937	0.914	0.923	
SE	0.023	0.022	0.016	
90% CI (+/-)	0.038	0.036	0.026	

* Includes dislodged tags and stationary signals.

** Fish classified as functionally dead at 48 h assessment, likely not capable of migrating to ocean.

Table 3-2

Summary malady data and malady-free estimates for adult European eels, passed through Turbine Unit 3, near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge. Proportions are given in parentheses.

	Turbine Unit 3			Controls
	Tip	**Mid**	**Combined**	
Number released	112	163	275	50
Number examined for maladies	108 (0.964)	155 (0.951)	263 (0.956)	50 (1.000)
Number with passage related maladies	10 (0.089)	12 (0.074)	22 (0.080)	0 (0.000)
Visible injuries	8 (0.071)	10 (0.061)	18 (0.065)	0 (0.000)
Loss of equilibrium only	2 (0.018)	2 (0.012)	4 (0.015)	0 (0.000)
Number without passage related maladies	98 (0.875)	143 (0.877)	241 (0.876)	50 (1.000)
Without passage related maladies that died	0 (0.000)	0 (0.000)	0 (0.000)	0 (0.000)
Malady free rate	0.907*	0.923	0.916	
SE	0.028	0.022	0.017	
90% CI (+/-)	0.046	0.035	0.028	

Estimates not significantly different (P > 0.10)

Table 3-3

Summary of visible injury types (passage induced) and injury rates observed on recaptured adult European eels, released through Turbine Unit 3, near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge.

			Injury Type*			
No. Released	No. Examined	Passage Related Visibly Injured	Gills Hemorrhaged	Severed or Nearly Severed	Bruised Head/Body	Internal Damage Hemorrhage, Broken Back Bone
			Tip			
112	108 (0.964)	8 (0.074)	1 (0.009)	2 (0.019)	5 (0.046)	1 (0.009)
			Mid			
163	155 (0.951)	10 (0.065)	4 (0.026)	1 (0.006)	7 (0.045)	2 (0.013)
			Combined			
275	263 (0.956)	18 (0.068)	5 (0.019)	3 (0.011)	12 (0.046)	3 (0.011)
			Controls			
50	50 (1.000)	0 (0.000)	0 (0.000)	0 (0.000)	0 (0.000)	0 (0.000)

*Some fish had multiple injury types

Table 3-4

Incidence of maladies, including visible injury, and temporary loss of equilibrium (LOE) observed on adult European eels, passed through Unit 3 near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge.

Date	Test Lot	Fish VI	Live/Dead	Maladies	Passage Malady*	Photo	Probable Cause	Status
				Tip				
9/7/10	2	629	alive	LOE; Damaged gills: both bleeding	Yes	No	Mechanical	Major
9/7/10	2	687	alive	Bruised whole length of fish	Yes	No	Mechanical	Major
9/7/10	2	633**	dead 48h	Bruised left side of body and tail; LOE; Classified as functionally dead at 48 h	Yes	Yes	Mechanical	Major
9/7/10	2	675	dead 1h	Severed body: lost about 18 cm from tail	Yes	Yes	Mechanical	Major
9/10/10	5	847	alive	LOE; Bruised on head	Yes	No	Mechanical	Minor
9/10/10	5	856	alive	Bruised on head	Yes	No	Mechanical	Minor
9/10/10	5	857	alive	Severe LOE	Yes	No		Minor
9/10/10	5	876	alive	Severe LOE	Yes	No		Minor
9/10/10	5	872	dead 1h	Severed body: back half of fish recaptured	Yes	Yes	Mechanical	Major
9/10/10	5	846	dead 24h	LOE; Bruised left side of body; Broken backbone	Yes	Yes	Mechanical	Major
				Mid				
9/6/10	1	657	alive	Damaged gill: bleeding, recapture injury	No	No	Tag/Recapture	
9/8/10	3	601	dead 24h	Damaged gills: bleeding from gills and mouth; LOE; Bruised head and along body; Hemorrhaged	Yes	Yes	Mechanical	Major
9/9/10	4	802	alive	LOE; Hemorrhaged from anus to tail	Yes	No	Mechanical	Major
9/11/10	6	964**	dead 48h	Laceration: tear in mid section, broken backbone; Classified as functionally dead at 48 h	Yes	Yes	Mechanical	Major
9/11/10	6	940	alive	LOE	Yes	No		Minor
9/11/10	6	942	dead 48h	Hemorrhaged internally from head to insertion of dorsal fin	Yes	Yes	Mechanical	Major
9/11/10	6	3	alive	LOE; Bruised tail	Yes	No	Mechanical	Major
9/11/10	6	929	dead 24h	Bruised on head and ventral side along entire tail	Yes	Yes	Mechanical	Major
9/11/10	6	951	dead 24h	Recaptured with severe LOE; Necropsied, no obvious injuries	Yes	No	Undetermined	Major
9/11/10	6	959	dead 24h	Damaged both eyes: hemorrhaged; Bruised approximately 25 cm along right side behind eye to	Yes	Yes	Mechanical	Major
9/13/10	7	392	alive	LOE; Bruised back end of body; Damaged right gill: hemorrhaged	Yes	No	Mechanical	Major
9/13/10	7	983	alive	Damaged gill: bleeding from both sides	Yes	No	Mechanical	Major
9/13/10	7	381	dead 24h	LOE; Damaged gill: bleeding; Hemorrhaged on head, (hit on head); Necropsied, no obvious injuries in body cavity.	Yes	Yes	Mechanical	Major

* Visible injury and/or loss of equilibrium attributed to turbine passage.

**Functionally dead, likely not capable of migrating to ocean.

Table 3-5

Probable sources and severity of maladies observed on recaptured adult European eels, released through Turbine Unit 3, near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge. Proportions are given in parentheses.

No. of Fish Examined	Total With Maladies	Mechanical	Undetermined	Severity	
				Minor	Major
		Tip			
108	10 (0.093)	8 (0.074)	2 (0.019)	4 (0.037)	6 (0.056)
		Mid			
155	12 (0.077)	10 (0.065)	2 (0.013)	1 (0.006)	11 (0.071)
		Combined			
263	22 (0.084)	18 (0.068)	4 (0.015)	5 (0.019)	17 (0.065)
		Controls			
50	0 (0.000)	0 (0.000)	0 (0.000)	0 (0.000)	0 (0.000)

FIGURES

Figure 1-1 Map of the Rhone River.

Figure 2-1 Crane positioning fish release pipes into the intake gate slot of Turbine Unit 3 at Beaucaire Power Station.

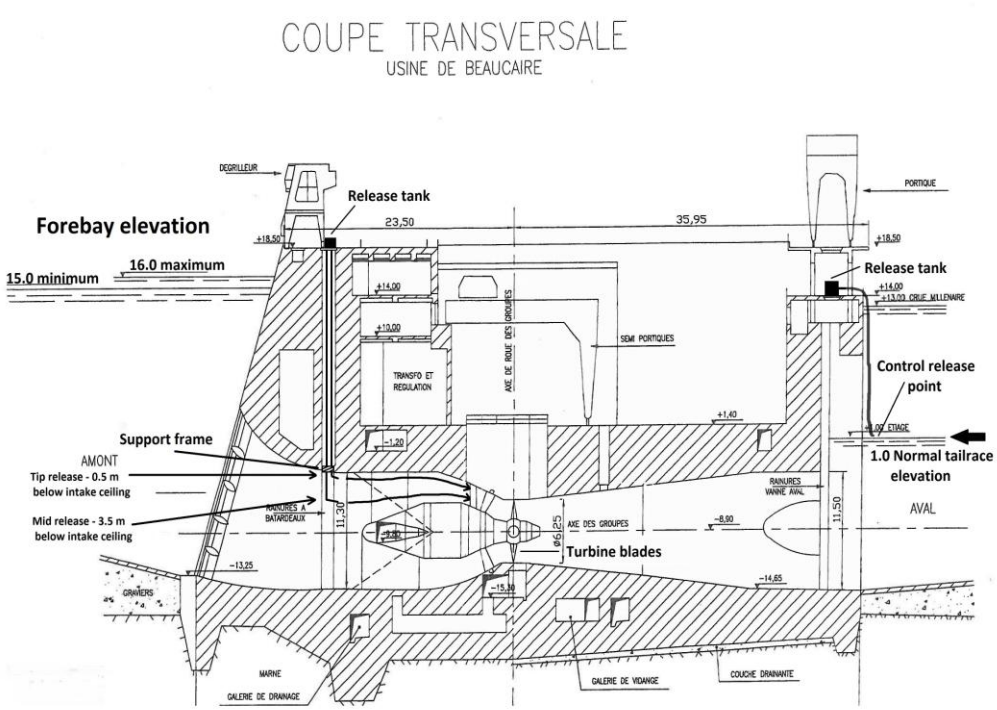

Figure 2-2 Cross section of Beaucaire Power Station with release locations and pipes.

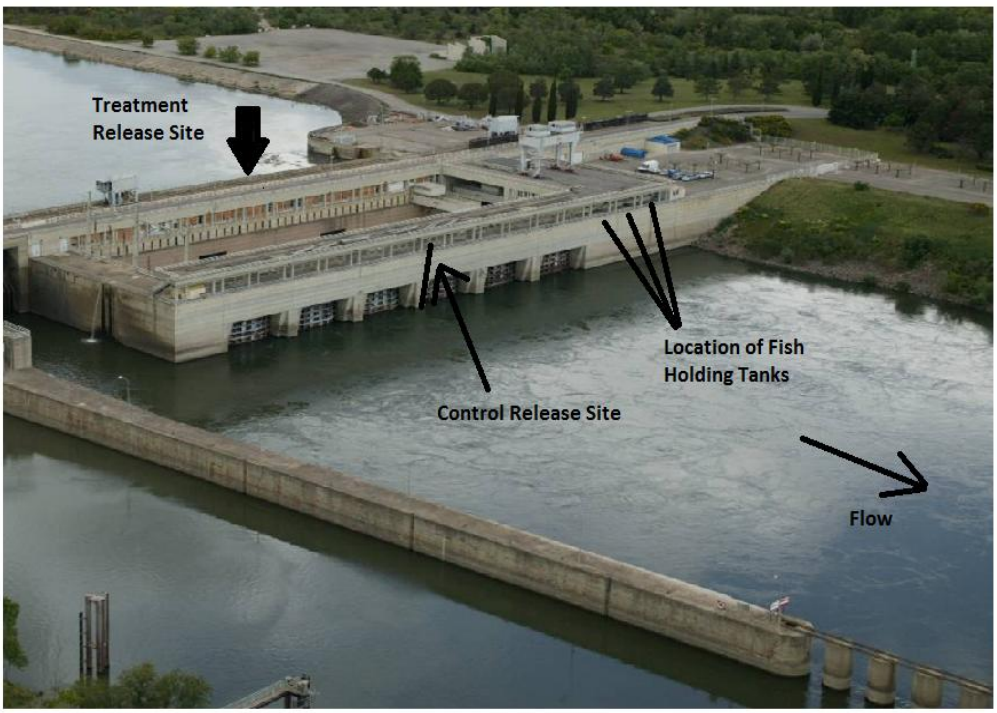

Figure 2-3 Aerial view of Beaucaire Power Station showing eel release and holding sites.

Figure 2-4 Holding pools for test eels.

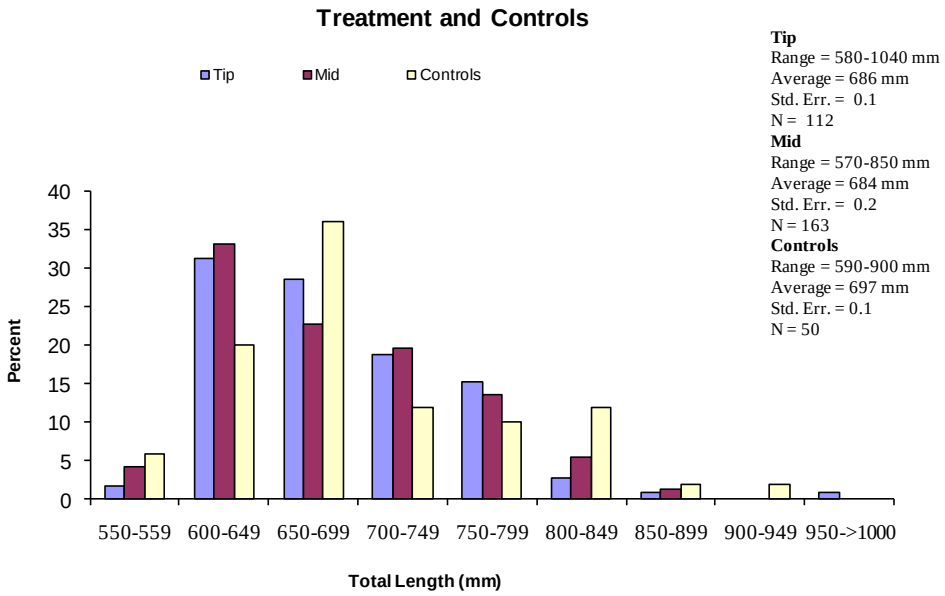

Figure 2-5 Total length (mm) frequency distribution of treatment and control adult European eels passed through Turbine Unit 3 near blade tip and near mid blade and discharging approximately 300 m³/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge.

Figure 2-6 Cannula needle with HI-Z balloon tags and ATS radio tag.

Figure 2-7 Induction apparatus for the release of control eels.

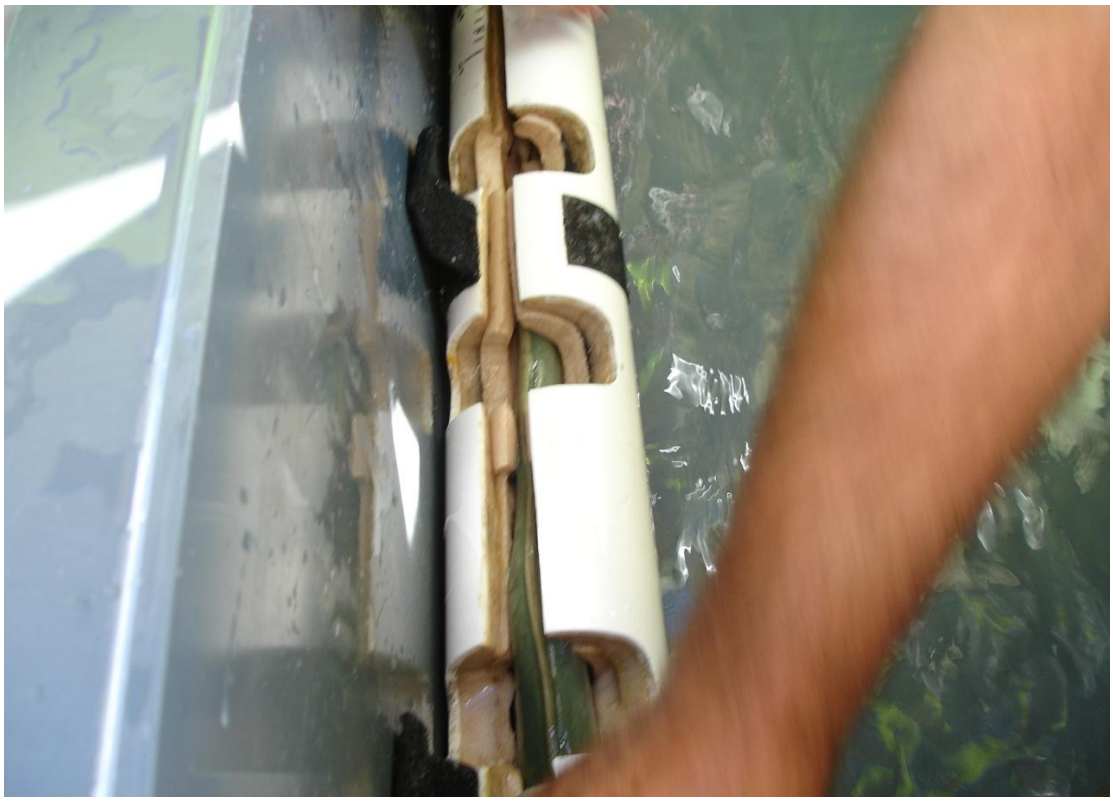

Figure 2-8 Positioning eel in restraining tube prior to activation of shocking device.

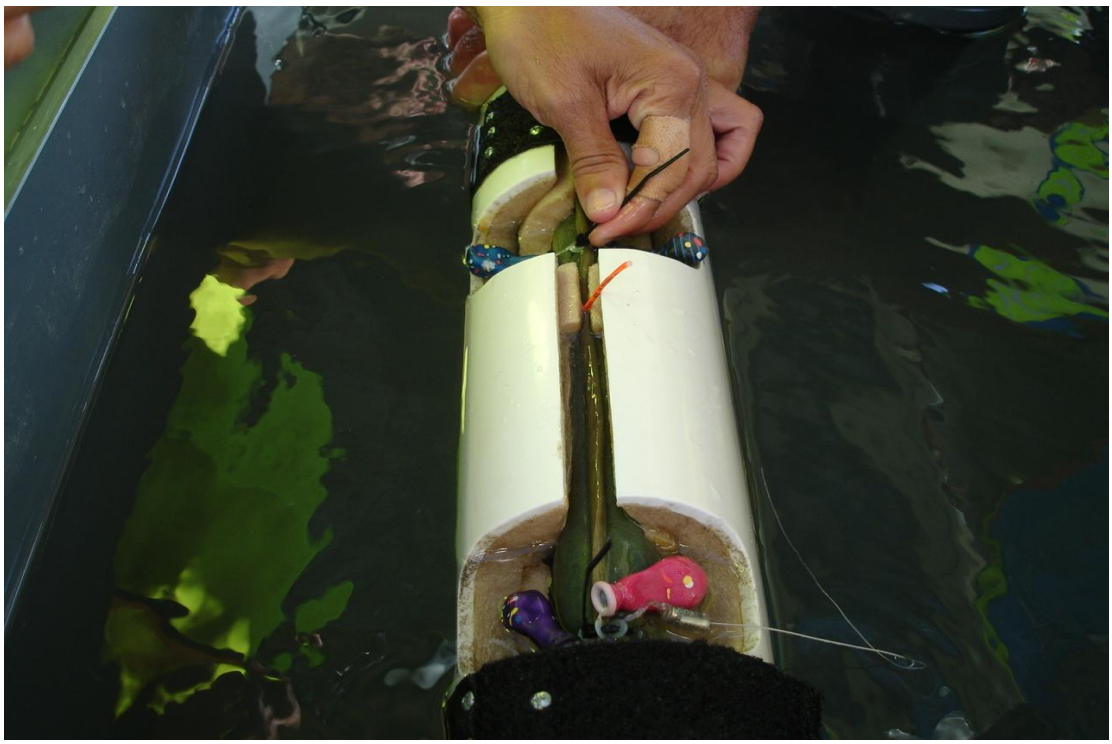

Figure 2-9 Attaching HI-Z tags on eels with zip ties.

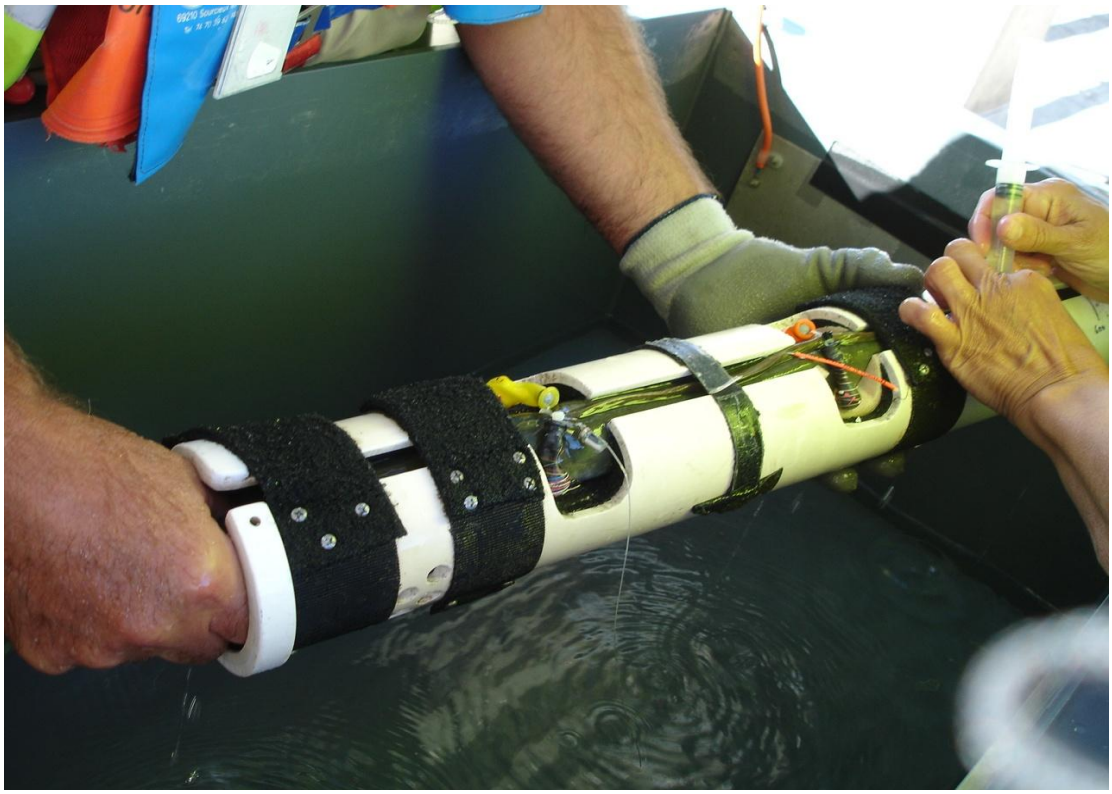

Figure 2-10 Activating HI-Z balloon tags.

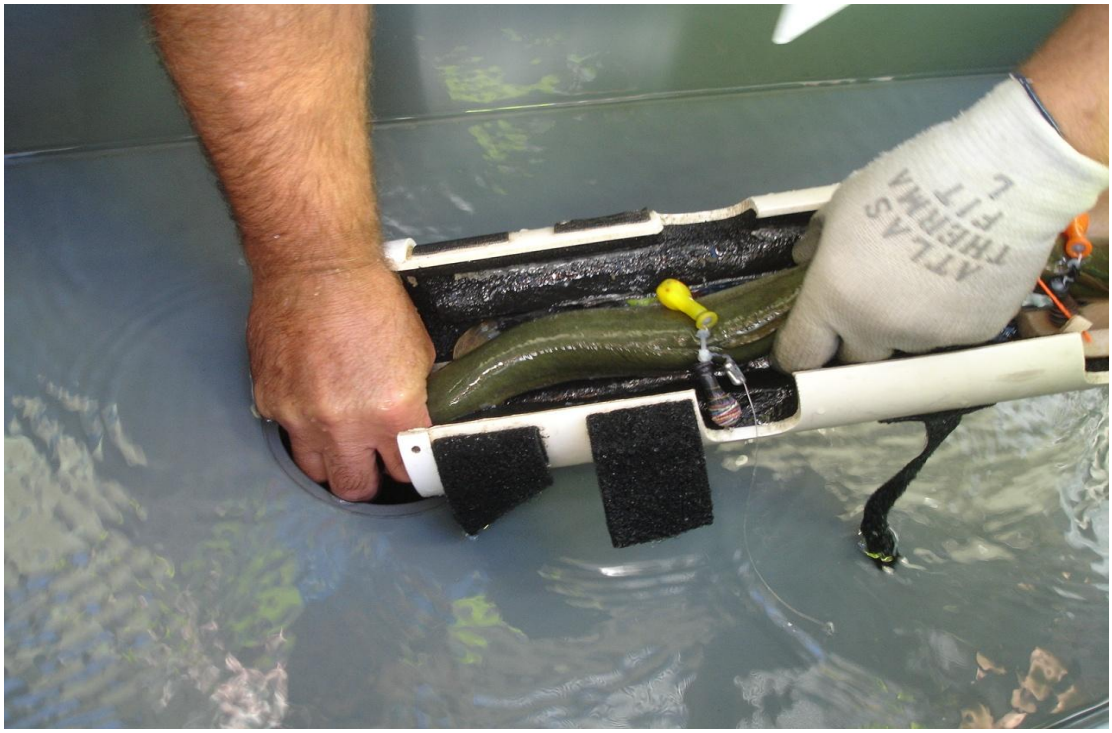

Figure 2-11 Releasing eels.

Figure 2-12 Induction site for release of test eels.

Figure 2-13 Hoses which directed eels to the desired release points.

Figure 2-14 Eel/recapture crews tracking turbine passed eels with loop antenna.

Figure 2-15 Listening for tagged released eels on large Yagi antenna.

Figure 2-16 Eel buoyed to surface.

Figure 2-17 Photo of eel buoyed to surface.

Figure 2-18 Harvesting buoyed eel.

Figure 2-19 Harvested turbine passed buoyed eel.

Figure 2-20 Example of bruising.

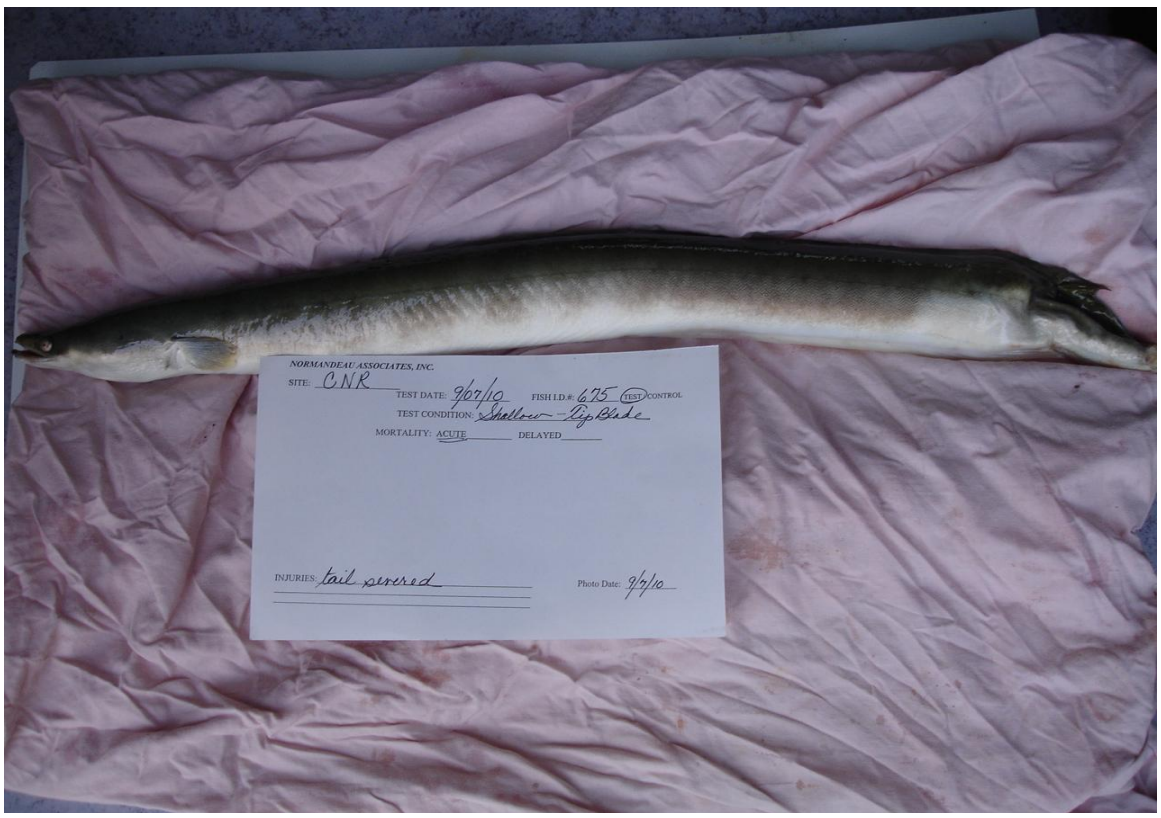

Figure 2-21 Severed tail.

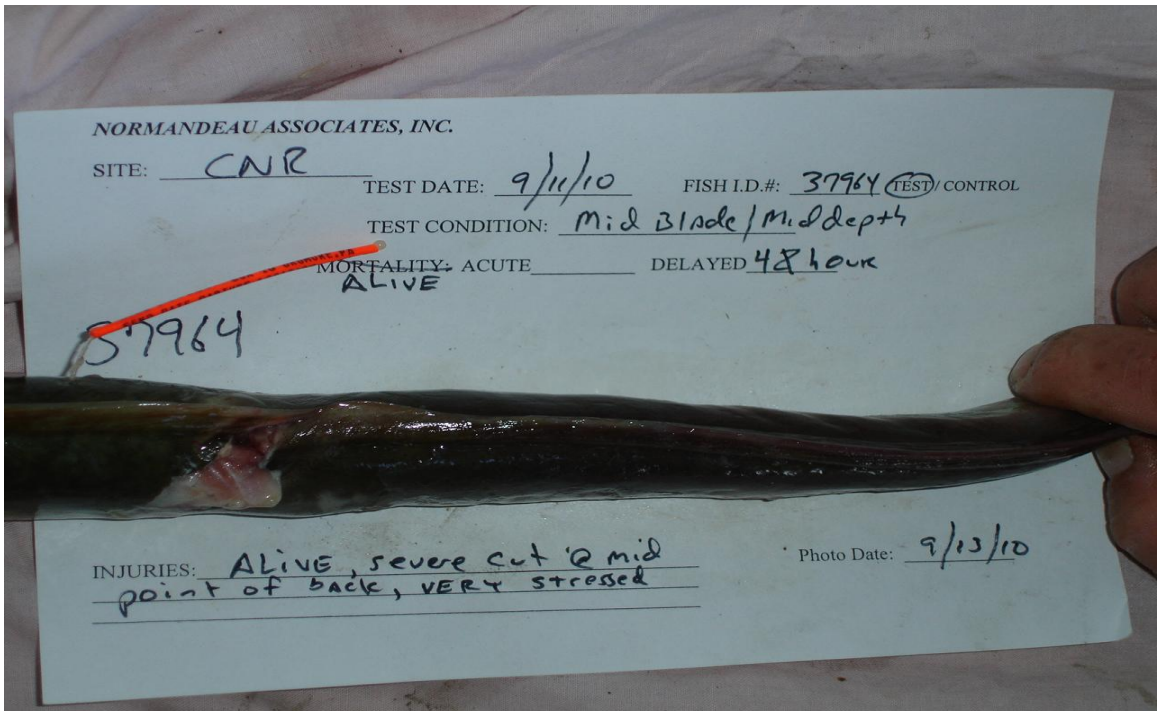

Figure 2-22 Eel with severe cut.

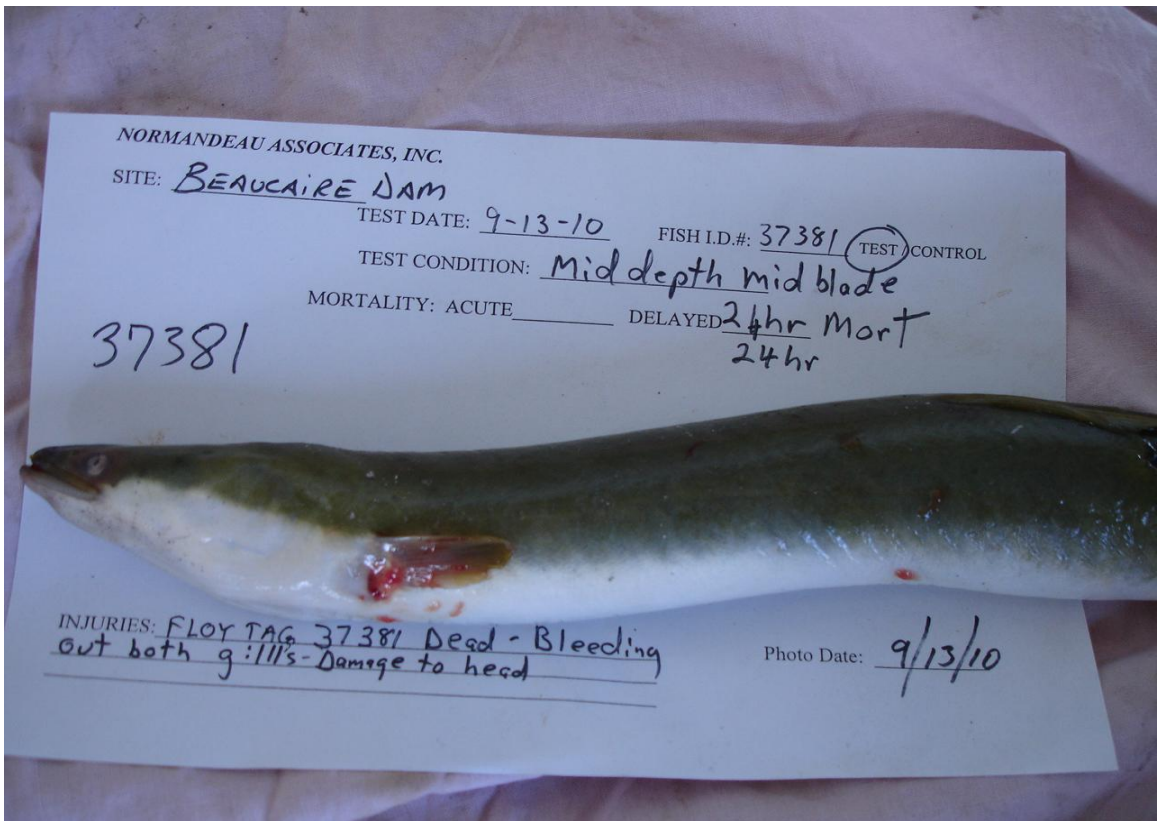

Figure 2-23 Example of internal injury.

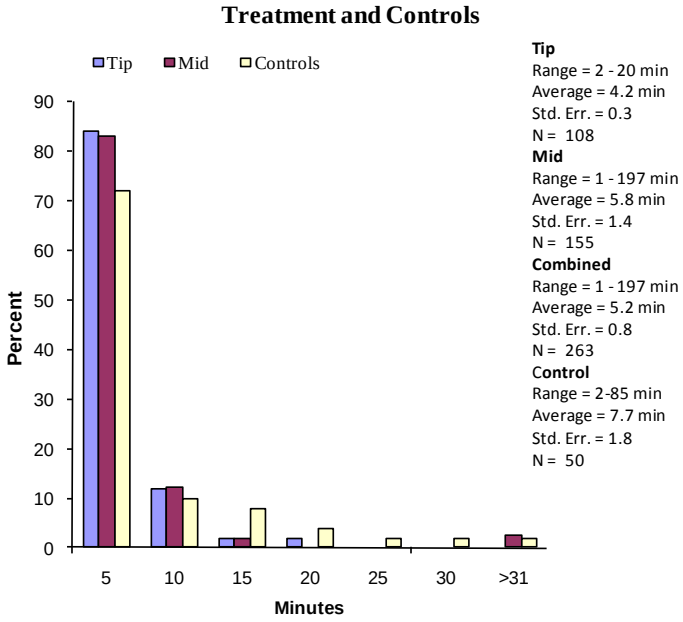

Figure 3-1 **Frequency distribution of retrieval times (minutes) of treatment and control adult European eels passed through Turbine Unit 3 near blade tip and near mid blade and discharging approximately 300 m³/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge.**

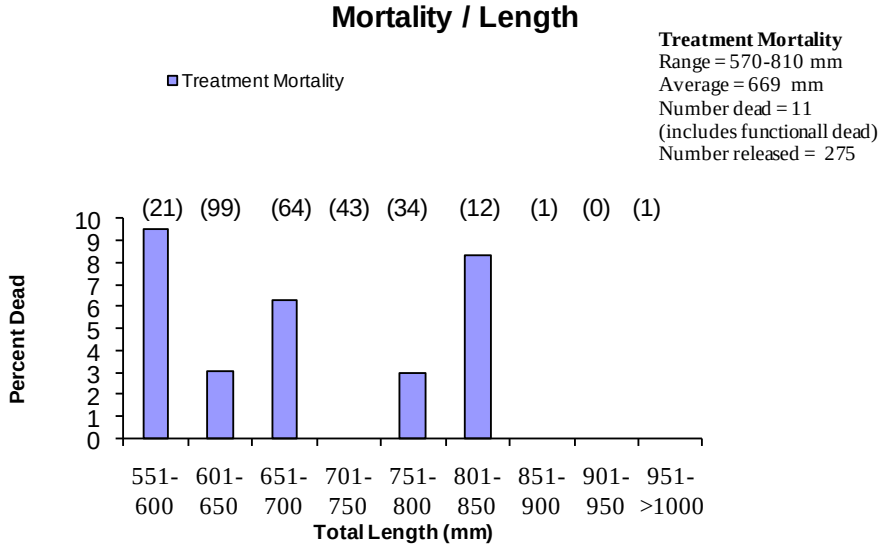

Figure 3-2 **Comparison of mortality versus length of adult European eels passed through Turbine Unit 3, at two depths near blade tip and near mid blade and discharging approximately 300 m³/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge. Number of fish released per 50 mm length interval shown in parenthesis (#).**

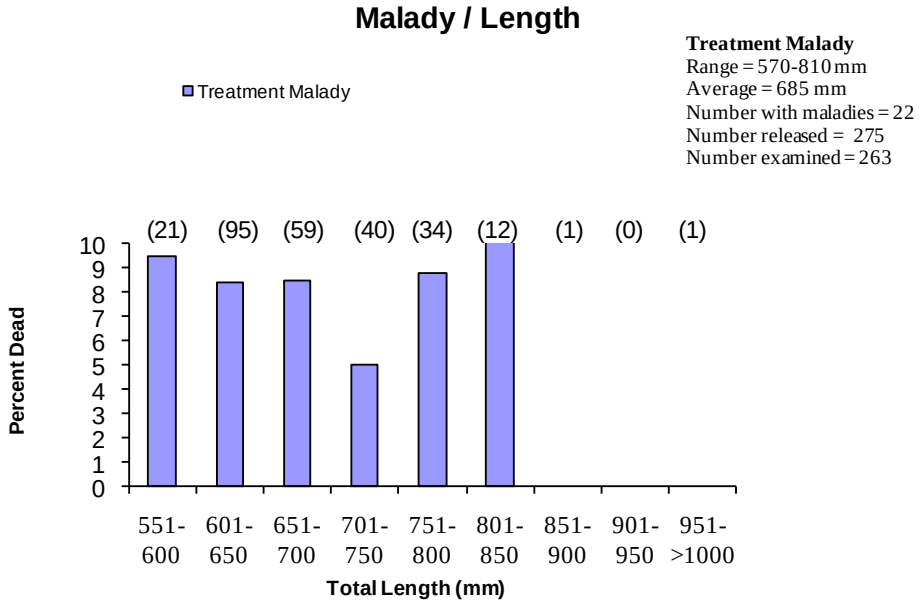

Figure 3-3 **Comparison of malady versus length of adult European eels passed through Turbine Unit 3, at two depths near blade tip and near mid blade and discharging approximately 300 m³/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge. Number of fish released per 50 mm length interval shown in parenthesis (#).**

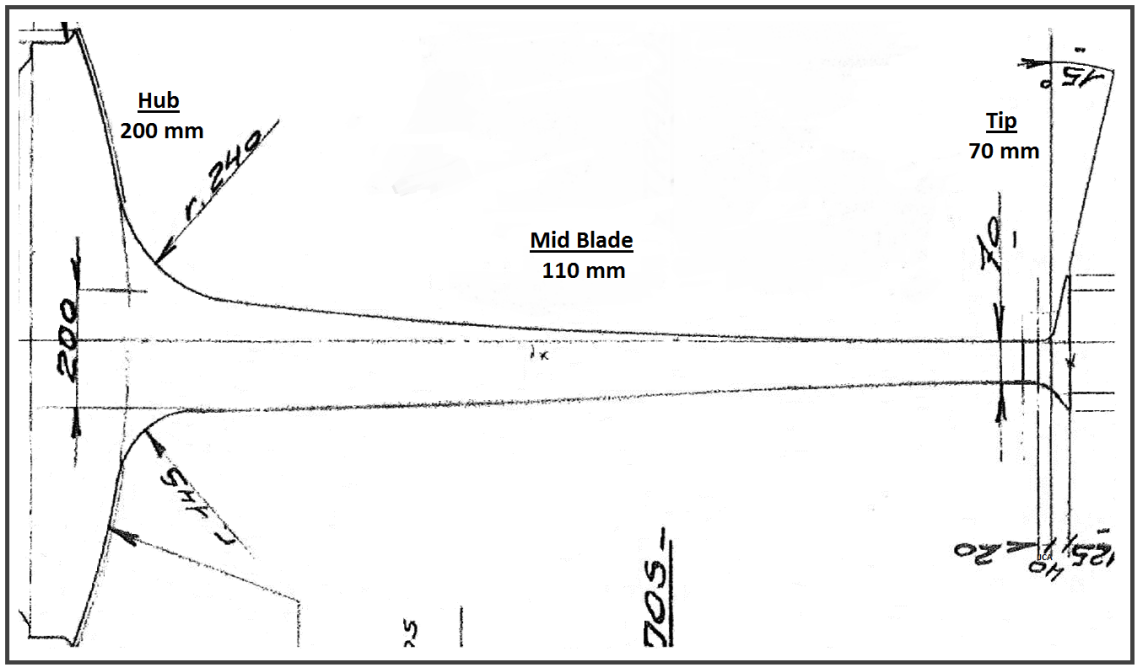

Figure 4-1 **Cross section of turbine blade from the Beaucaire Station showing maximum width from hub to tip.**

Figure 6-1 Those who assisted with the completion of the study.

APPENDIX

APPENDIX TABLE A

Appendix Table A-1

Station parameters measured for adult European eels, released through Turbine Unit 3 near blade tip and near mid blade and discharging approximately 300 m3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/6/2010 14:13	36.5	control	15.7	1.6	14.0	308	1134.4
9/6/2010 14:15	36.6	control	15.6	1.6	14.0	308	1137.6
9/6/2010 14:16	36.8	control	15.6	1.6	14.0	310	1142.6
9/6/2010 14:18	36.8	control	15.6	1.6	14.0	310	1140.8
9/6/2010 14:20	36.4	control	15.6	1.6	14.0	308	1137.8
9/6/2010 14:21	36.1	control	15.6	1.6	14.0	305	1131.6
9/6/2010 14:23	36.0	control	15.6	1.6	14.0	305	1131.8
9/6/2010 14:25	35.9	control	15.6	1.7	14.0	305	1129.2
9/6/2010 14:26	36.1	control	15.6	1.7	14.0	310	1141.5
9/6/2010 14:28	35.9	control	15.6	1.7	14.0	305	1132.7
9/6/2010 14:30	35.7	control	15.6	1.7	14.0	299	1125.0
9/6/2010 14:31	35.9	control	15.6	1.7	14.0	302	1125.0
9/6/2010 14:33	36.3	control	15.6	1.7	14.0	310	1132.7
9/6/2010 14:35	36.6	control	15.6	1.7	14.0	308	1144.0
9/6/2010 14:36	36.5	control	15.6	1.7	14.0	310	1144.0
9/6/2010 14:38	36.6	control	15.6	1.7	14.0	308	1141.7
9/6/2010 14:40	36.2	control	15.6	1.6	14.0	305	1135.5
9/6/2010 14:41	36.4	control	15.6	1.6	14.0	308	1132.5
9/6/2010 14:43	35.9	control	15.6	1.6	14.0	305	1132.2
9/6/2010 14:45	36.0	control	15.6	1.6	14.0	305	1132.2
9/6/2010 14:46	36.5	control	15.6	1.6	14.0	308	1143.2
9/6/2010 14:48	36.0	control	15.6	1.6	14.0	302	1127.5
9/6/2010 14:50	35.8	control	15.6	1.6	14.0	302	1124.7
9/6/2010 14:51	35.5	control	15.6	1.6	14.0	302	1124.7
9/6/2010 14:53	36.3	control	15.6	1.6	14.0	305	871.0
9/6/2010 14:55	36.6	control	15.6	1.6	14.0	308	885.0
9/6/2010 14:56	36.6	control	15.6	1.6	14.0	305	923.7
9/6/2010 14:58	36.8	control	15.6	1.6	14.0	308	930.8
9/6/2010 15:00	37.2	control	15.7	1.6	14.1	310	933.0
9/6/2010 15:01	37.8	control	15.7	1.6	14.1	316	915.0
9/6/2010 15:03	37.7	control	15.7	1.6	14.1	319	923.0
9/6/2010 15:05	37.7	control	15.7	1.6	14.1	313	918.0
9/6/2010 15:06	37.7	control	15.7	1.6	14.1	316	918.0
9/6/2010 15:08	36.7	control	15.7	1.6	14.1	308	895.0
9/6/2010 15:10	36.8	control	15.7	1.5	14.1	308	898.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/6/2010 15:11	36.9	control	15.6	1.5	14.1	310	895.0
9/6/2010 15:13	36.4	control	15.6	1.5	14.1	305	886.0
9/6/2010 15:15	36.6	control	15.6	1.5	14.1	302	878.0
9/6/2010 15:16	37.3	control	15.6	1.5	14.1	313	922.9
9/6/2010 15:18	36.7	control	15.6	1.5	14.1	310	922.7
9/6/2010 15:20	36.4	control	15.6	1.5	14.1	302	911.7
9/6/2010 15:21	36.5	control	15.6	1.5	14.1	305	911.9
9/6/2010 15:23	36.4	control	15.6	1.5	14.1	302	912.1
9/6/2010 15:25	36.2	control	15.6	1.5	14.1	302	909.1
9/6/2010 15:26	36.2	control	15.6	1.5	14.1	305	912.3
9/6/2010 15:28	35.9	control	15.6	1.5	14.1	299	904.1
9/6/2010 15:30	36.5	control	15.6	1.5	14.1	302	908.7
9/6/2010 15:31	37.4	control	15.6	1.5	14.1	310	925.5
9/6/2010 15:33	36.9	control	15.7	1.5	14.1	305	917.1
9/6/2010 15:35	36.7	control	15.7	1.5	14.2	308	913.9
9/6/2010 15:36	36.4	control	15.7	1.5	14.2	302	902.6
9/6/2010 15:38	36.2	control	15.6	1.5	14.2	299	902.2
9/6/2010 15:40	36.5	control	15.6	1.5	14.2	302	910.2
9/6/2010 15:41	36.5	control	15.6	1.5	14.2	305	907.2
9/6/2010 15:43	36.3	control	15.6	1.5	14.2	302	905.2
9/6/2010 15:45	36.4	control	15.6	1.5	14.2	302	907.2
9/6/2010 15:46	36.4	control	15.6	1.5	14.2	302	905.2
9/6/2010 15:48	36.3	control	15.6	1.5	14.2	302	907.2
9/6/2010 15:50	36.3	control	15.6	1.5	14.2	299	905.2
9/6/2010 16:15	36.6	Mid	15.6	1.4	14.2	308	916.0
9/6/2010 16:16	36.9	Mid	15.6	1.4	14.2	308	919.0
9/6/2010 16:18	37.1	Mid	15.6	1.4	14.2	310	919.2
9/6/2010 16:20	37.3	Mid	15.6	1.4	14.2	310	921.0
9/6/2010 16:21	37.6	Mid	15.6	1.4	14.2	310	926.8
9/6/2010 16:23	37.4	Mid	15.6	1.4	14.2	308	915.8
9/6/2010 16:25	37.2	Mid	15.7	1.4	14.2	305	915.4
9/6/2010 16:26	37.2	Mid	15.7	1.4	14.2	308	920.4
9/6/2010 16:28	37.3	Mid	15.7	1.4	14.2	308	915.0
9/6/2010 16:30	36.9	Mid	15.7	1.4	14.2	305	915.0
9/6/2010 16:31	37.6	Mid	15.7	1.4	14.2	313	926.0
9/6/2010 16:33	37.2	Mid	15.7	1.4	14.2	313	926.2

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/6/2010 16:35	37.7	Mid	15.6	1.4	14.2	316	932.4
9/6/2010 16:36	37.6	Mid	15.6	1.4	14.2	310	926.4
9/6/2010 16:38	37.5	Mid	15.6	1.4	14.2	310	920.4
9/6/2010 16:40	37.3	Mid	15.6	1.4	14.2	308	918.6
9/6/2010 16:41	37.1	Mid	15.6	1.4	14.2	308	918.6
9/6/2010 16:43	36.9	Mid	15.6	1.4	14.2	305	912.4
9/6/2010 16:45	37.2	Mid	15.6	1.4	14.2	308	920.2
9/6/2010 16:46	36.9	Mid	15.6	1.4	14.2	305	912.4
9/6/2010 16:48	36.6	Mid	15.6	1.4	14.2	302	909.6
9/6/2010 16:50	36.6	Mid	15.6	1.4	14.2	308	912.8
9/6/2010 16:51	37.3	Mid	15.6	1.5	14.2	310	926.8
9/6/2010 16:53	36.9	Mid	15.6	1.5	14.2	308	916.0
9/6/2010 16:55	36.7	Mid	15.6	1.5	14.2	308	916.0
9/6/2010 16:56	36.7	Mid	15.6	1.4	14.2	305	913.0
9/6/2010 16:58	37.1	Mid	15.6	1.4	14.2	308	918.8
9/6/2010 17:00	37.1	Mid	15.7	1.4	14.2	305	909.4
9/6/2010 17:33	37.5	Tip	15.7	1.4	14.3	308	917.5
9/6/2010 17:35	36.9	Tip	15.7	1.4	14.3	305	911.3
9/6/2010 17:36	37.0	Tip	15.7	1.4	14.3	308	914.3
9/6/2010 17:38	37.3	Tip	15.7	1.4	14.3	310	914.1
9/6/2010 17:40	36.9	Tip	15.7	1.4	14.3	305	911.1
9/6/2010 17:41	37.2	Tip	15.7	1.4	14.3	308	911.1
9/6/2010 17:43	36.8	Tip	15.7	1.4	14.3	302	905.1
9/6/2010 17:45	36.8	Tip	15.7	1.4	14.3	302	900.3
9/6/2010 17:46	37.2	Tip	15.7	1.4	14.3	308	919.3
9/6/2010 17:48	37.2	Tip	15.7	1.4	14.3	308	901.0
9/6/2010 17:50	37.3	Tip	15.7	1.4	14.3	308	901.0
9/6/2010 17:51	37.2	Tip	15.7	1.4	14.3	305	901.0
9/6/2010 17:53	37.1	Tip	15.7	1.4	14.3	308	895.0
9/6/2010 17:55	37.5	Tip	15.7	1.4	14.3	308	914.5
9/6/2010 17:56	37.4	Tip	15.7	1.4	14.3	305	911.3
9/6/2010 17:58	37.2	Tip	15.7	1.4	14.3	308	911.5
9/6/2010 18:00	36.7	Tip	15.7	1.4	14.3	299	897.3
9/6/2010 18:01	36.9	Tip	15.7	1.4	14.3	308	897.0
9/6/2010 18:03	36.9	Tip	15.7	1.4	14.3	305	897.0
9/6/2010 18:05	37.3	Tip	15.7	1.4	14.3	310	895.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/6/2010 18:06	37.7	Tip	15.7	1.4	14.3	308	895.0
9/6/2010 18:08	37.5	Tip	15.7	1.4	14.3	310	897.0
9/6/2010 18:10	37.7	Tip	15.7	1.4	14.3	310	903.0
9/6/2010 18:11	37.8	Tip	15.7	1.4	14.3	313	925.1
9/6/2010 18:13	37.4	Tip	15.7	1.4	14.3	310	919.1
9/6/2010 18:15	37.3	Tip	15.7	1.4	14.3	310	922.1
9/6/2010 18:16	37.7	Tip	15.7	1.4	14.3	313	925.3
9/6/2010 18:18	37.7	Tip	15.7	1.4	14.3	310	925.5
9/7/2010 10:00	34.7	Tip	15.5	2.1	13.4	310	1252.9
9/7/2010 10:01	34.3	Tip	15.5	2.1	13.4	310	1249.6
9/7/2010 10:03	34.8	Tip	15.5	2.1	13.4	313	1255.6
9/7/2010 10:05	34.5	Tip	15.5	2.1	13.4	310	1255.6
9/7/2010 10:06	35.0	Tip	15.5	2.1	13.4	313	1258.6
9/7/2010 10:08	34.7	Tip	15.5	2.1	13.4	313	1258.6
9/7/2010 10:10	34.9	Tip	15.5	2.1	13.4	313	1264.9
9/7/2010 10:11	34.5	Tip	15.5	2.1	13.4	310	1247.9
9/7/2010 10:13	34.7	Tip	15.5	2.1	13.4	310	1247.9
9/7/2010 10:15	34.7	Tip	15.5	2.1	13.4	310	1252.9
9/7/2010 10:16	34.5	Tip	15.5	2.1	13.4	313	1259.1
9/7/2010 10:18	35.3	Tip	15.5	2.1	13.4	316	1262.1
9/7/2010 10:20	35.4	Tip	15.5	2.1	13.4	313	1265.1
9/7/2010 10:21	35.2	Tip	15.5	2.1	13.4	316	1267.9
9/7/2010 10:23	35.3	Tip	15.5	2.1	13.4	316	1267.6
9/7/2010 10:25	34.9	Tip	15.5	2.1	13.4	313	1264.4
9/7/2010 10:26	34.8	Tip	15.5	2.1	13.4	310	1255.4
9/7/2010 10:28	34.9	Tip	15.5	2.1	13.4	313	1258.2
9/7/2010 10:30	35.1	Tip	15.5	2.1	13.4	316	1264.4
9/7/2010 10:31	35.4	Tip	15.5	2.1	13.4	316	1264.4
9/7/2010 10:33	34.9	Tip	15.5	2.1	13.4	316	1267.4
9/7/2010 10:35	35.1	Tip	15.5	2.1	13.4	313	1267.6
9/7/2010 10:36	34.9	Tip	15.5	2.1	13.4	316	1267.6
9/7/2010 10:38	35.1	Tip	15.5	2.1	13.4	313	1261.9
9/7/2010 10:40	34.8	Tip	15.5	2.1	13.4	310	1249.9
9/7/2010 10:41	35.1	Tip	15.5	2.1	13.4	313	1261.9
9/7/2010 10:43	35.1	Tip	15.5	2.1	13.4	316	1273.9
9/7/2010 10:45	35.0	Tip	15.5	2.1	13.4	316	1270.6

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/7/2010 10:46	34.8	Tip	15.5	2.1	13.4	316	1270.9
9/7/2010 10:48	35.4	Tip	15.5	2.1	13.4	319	1267.9
9/7/2010 10:50	35.1	Tip	15.5	2.1	13.4	316	1267.6
9/7/2010 10:51	34.8	Tip	15.5	2.1	13.4	313	1261.6
9/7/2010 10:53	35.1	Tip	15.5	2.1	13.4	310	1261.9
9/7/2010 10:55	34.7	Tip	15.5	2.1	13.4	313	1258.6
9/7/2010 10:56	34.5	Tip	15.5	2.1	13.4	310	1247.6
9/7/2010 10:58	34.9	Tip	15.5	2.1	13.4	310	1252.6
9/7/2010 11:00	35.0	Tip	15.5	2.1	13.4	308	1249.6
9/7/2010 11:01	34.9	Tip	15.5	2.1	13.4	310	1249.6
9/7/2010 11:03	34.5	Tip	15.5	2.1	13.4	308	1249.6
9/7/2010 11:05	34.9	Tip	15.5	2.1	13.4	310	1255.4
9/7/2010 11:06	34.9	Tip	15.5	2.1	13.4	313	1258.4
9/7/2010 11:08	35.0	Tip	15.5	2.1	13.4	313	1252.4
9/7/2010 11:10	35.3	Tip	15.5	2.1	13.4	313	1264.2
9/7/2010 11:11	35.3	Tip	15.6	2.1	13.4	316	1273.2
9/7/2010 11:13	35.3	Tip	15.6	2.1	13.4	316	1269.9
9/7/2010 11:15	35.3	Tip	15.6	2.1	13.4	313	1260.7
9/7/2010 11:16	35.4	Tip	15.6	2.1	13.4	313	1266.7
9/7/2010 11:18	35.1	Tip	15.6	2.1	13.4	313	1260.7
9/7/2010 11:20	35.3	Tip	15.6	2.1	13.4	310	1260.7
9/7/2010 11:21	35.0	Tip	15.6	2.1	13.4	316	1263.7
9/7/2010 11:23	34.9	Tip	15.6	2.1	13.4	313	1254.7
9/7/2010 11:25	35.2	Tip	15.6	2.1	13.4	313	1260.7
9/7/2010 11:26	34.8	Tip	15.6	2.1	13.4	310	1248.7
9/7/2010 11:28	34.8	Tip	15.6	2.1	13.4	308	1248.7
9/7/2010 11:30	34.8	Tip	15.6	2.1	13.4	313	1257.4
9/7/2010 11:31	35.5	Tip	15.6	2.1	13.4	319	1269.4
9/7/2010 11:33	35.3	Tip	15.6	2.1	13.4	313	1263.4
9/7/2010 11:35	35.3	Tip	15.6	2.1	13.4	313	1266.4
9/7/2010 11:36	35.4	Tip	15.6	2.1	13.4	313	1260.4
9/7/2010 11:38	35.4	Tip	15.6	2.1	13.4	310	1254.4
9/7/2010 11:40	35.3	Tip	15.6	2.1	13.4	313	1260.4
9/7/2010 11:41	35.5	Tip	15.6	2.1	13.4	316	1266.4
9/7/2010 11:43	35.2	Tip	15.6	2.1	13.4	313	1257.4
9/7/2010 11:45	35.5	Tip	15.6	2.1	13.4	316	1266.4
9/7/2010 11:46	35.3	Tip	15.6	2.1	13.5	313	1263.4

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/7/2010 11:48	35.5	Tip	15.6	2.1	13.5	316	1266.2
9/7/2010 11:50	35.4	Tip	15.6	2.1	13.5	316	1266.2
9/7/2010 11:51	35.9	Tip	15.6	2.1	13.5	316	1275.2
9/7/2010 11:53	34.8	Tip	15.6	2.1	13.5	308	1251.2
9/7/2010 11:55	35.2	Tip	15.6	2.1	13.4	313	1257.4
9/7/2010 11:56	35.4	Tip	15.6	2.1	13.4	313	1263.4
9/7/2010 11:58	34.9	Tip	15.6	2.1	13.4	310	1248.4
9/7/2010 12:00	34.2	Tip	15.6	2.1	13.4	305	1235.7
9/7/2010 12:01	35.2	Tip	15.6	2.2	13.4	319	1287.6
9/7/2010 12:03	35.7	Tip	15.6	2.2	13.4	316	1288.5
9/7/2010 12:05	35.0	Tip	15.6	2.2	13.4	310	1290.4
9/7/2010 12:06	34.9	Tip	15.6	2.2	13.4	310	1290.4
9/7/2010 12:08	35.1	Tip	15.6	2.2	13.4	310	1291.3
9/7/2010 12:10	35.0	Tip	15.6	2.2	13.4	310	1290.4
9/7/2010 12:11	35.1	Tip	15.6	2.2	13.4	310	1291.3
9/7/2010 12:13	34.6	Tip	15.6	2.2	13.4	310	1289.5
9/7/2010 12:15	34.5	Tip	15.6	2.2	13.4	310	1289.5
9/7/2010 12:16	34.4	Tip	15.6	2.2	13.4	310	1288.5
9/7/2010 12:18	34.9	Tip	15.6	2.1	13.4	310	1287.6
9/7/2010 12:20	34.6	Tip	15.6	2.1	13.4	310	1286.6
9/7/2010 12:21	34.8	Tip	15.6	2.1	13.4	310	1286.6
9/7/2010 12:23	34.6	Tip	15.6	2.1	13.4	310	1286.6
9/7/2010 12:25	35.0	Tip	15.6	2.1	13.4	310	1286.6
9/7/2010 12:26	35.3	Tip	15.6	2.1	13.4	310	1286.6
9/7/2010 12:28	34.5	Tip	15.6	2.1	13.4	310	1286.6
9/7/2010 12:30	34.5	Tip	15.6	2.1	13.5	310	1285.7
9/7/2010 12:31	35.2	Tip	15.6	2.1	13.5	310	1284.8
9/7/2010 12:33	35.7	Tip	15.6	2.1	13.5	316	1283.8
9/7/2010 12:35	35.4	Tip	15.6	2.1	13.5	316	1283.8
9/7/2010 12:36	35.1	Tip	15.6	2.2	13.5	310	1285.7
9/7/2010 12:38	35.1	Tip	15.6	2.2	13.5	310	1285.7
9/7/2010 12:40	35.2	Tip	15.6	2.2	13.5	310	1285.7
9/7/2010 12:41	34.6	Tip	15.6	2.2	13.5	310	1285.7
9/7/2010 12:43	34.5	Tip	15.6	2.1	13.5	302	1284.8
9/7/2010 12:45	34.1	Tip	15.6	2.1	13.5	299	1283.8
9/7/2010 12:46	34.5	Tip	15.6	2.1	13.5	302	1283.8
9/7/2010 12:48	34.3	Tip	15.6	2.1	13.5	310	1283.8

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/7/2010 12:50	34.6	Tip	15.6	2.1	13.5	310	1283.8
9/7/2010 12:51	35.1	Tip	15.6	2.1	13.5	310	1282.9
9/7/2010 12:53	35.2	Tip	15.6	2.1	13.5	310	1281.9
9/7/2010 12:55	34.8	Tip	15.6	2.1	13.5	310	1282.9
9/7/2010 12:56	34.2	Tip	15.6	2.1	13.5	310	1283.8
9/7/2010 12:58	34.8	Tip	15.6	2.1	13.5	310	1283.8
9/7/2010 13:00	34.7	Tip	15.6	2.1	13.5	310	1283.8
9/7/2010 13:01	36.3	Tip	15.6	2.1	13.5	324	1282.9
9/7/2010 13:03	36.0	Tip	15.6	2.1	13.5	324	1283.8
9/7/2010 13:05	35.9	Tip	15.6	2.2	13.5	322	1284.8
9/7/2010 13:06	36.0	Tip	15.6	2.2	13.4	319	1285.7
9/7/2010 13:08	35.9	Tip	15.6	2.2	13.4	319	1288.5
9/7/2010 13:10	36.0	Tip	15.6	2.2	13.4	322	1287.6
9/7/2010 13:11	35.8	Tip	15.6	2.2	13.4	316	1287.6
9/7/2010 13:13	35.7	Tip	15.6	2.2	13.4	316	1286.6
9/7/2010 13:15	35.7	Tip	15.6	2.2	13.4	319	1286.6
9/7/2010 13:16	36.1	Tip	15.6	2.2	13.4	319	1286.6
9/7/2010 13:18	35.5	Tip	15.6	2.2	13.5	316	1285.7
9/7/2010 13:20	35.4	Tip	15.6	2.2	13.5	310	1284.8
9/7/2010 13:21	35.7	Tip	15.6	2.2	13.5	310	1284.8
9/7/2010 13:23	35.0	Tip	15.6	2.2	13.5	310	1284.8
9/7/2010 13:25	35.5	Tip	15.6	2.2	13.5	310	1283.8
9/7/2010 13:26	35.5	Tip	15.6	2.2	13.5	310	1283.8
9/7/2010 13:28	35.0	Tip	15.6	2.2	13.5	316	1283.8
9/7/2010 13:30	35.0	Tip	15.6	2.2	13.5	310	1282.9
9/7/2010 13:31	35.5	Tip	15.6	2.2	13.5	316	1282.9
9/7/2010 13:33	35.8	Tip	15.6	2.2	13.5	316	1282.9
9/7/2010 13:35	36.2	Tip	15.6	2.2	13.5	319	1282.9
9/7/2010 13:36	36.9	Tip	15.6	2.2	13.5	330	1287.7
9/7/2010 13:38	37.1	Tip	15.6	2.2	13.5	336	1294.2
9/7/2010 13:40	37.3	Tip	15.6	2.2	13.5	333	1294.2
9/7/2010 13:41	37.1	Tip	15.6	2.2	13.4	336	1294.4
9/7/2010 13:43	36.7	Tip	15.6	2.2	13.4	324	1273.7
9/7/2010 13:45	36.2	Tip	15.6	2.2	13.4	330	1276.7
9/7/2010 13:46	36.4	Tip	15.6	2.2	13.4	327	1276.9
9/7/2010 13:48	36.4	Tip	15.6	2.2	13.4	327	1270.9
9/7/2010 13:50	36.3	Tip	15.6	2.2	13.4	324	1269.2

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/7/2010 13:51	36.4	Tip	15.6	2.2	13.4	330	1277.2
9/7/2010 13:53	36.5	Tip	15.6	2.2	13.4	327	1276.9
9/7/2010 13:55	36.6	Tip	15.6	2.2	13.4	324	1276.4
9/7/2010 13:56	36.3	Tip	15.6	2.2	13.5	322	1264.0
9/7/2010 13:58	36.4	Tip	15.6	2.2	13.5	327	1267.7
9/7/2010 14:00	37.0	Tip	15.7	2.2	13.5	330	1284.5
9/7/2010 14:01	37.4	Tip	15.7	2.2	13.5	341	1326.5
9/7/2010 14:03	37.8	Tip	15.7	2.2	13.5	338	1328.5
9/7/2010 14:05	37.5	Tip	15.6	2.2	13.5	338	1323.7
9/7/2010 14:06	37.2	Tip	15.6	2.2	13.5	336	1313.7
9/7/2010 14:08	36.6	Tip	15.6	2.2	13.5	330	1301.7
9/7/2010 14:10	37.0	Tip	15.6	2.2	13.4	330	1305.4
9/7/2010 14:11	37.2	Tip	15.6	2.2	13.4	336	1308.4
9/7/2010 14:13	37.1	Tip	15.6	2.2	13.4	330	1299.7
9/7/2010 14:15	37.1	Tip	15.6	2.2	13.4	330	1302.9
9/7/2010 14:16	37.1	Tip	15.6	2.2	13.4	330	1305.9
9/7/2010 14:18	36.9	Tip	15.6	2.2	13.4	330	1302.9
9/7/2010 14:20	36.9	Tip	15.6	2.2	13.4	330	1302.9
9/7/2010 14:21	37.3	Tip	15.6	2.2	13.4	336	1314.9
9/7/2010 14:23	37.7	Tip	15.6	2.2	13.4	338	1319.7
9/7/2010 14:25	37.4	Tip	15.6	2.2	13.4	336	1314.7
9/7/2010 14:26	37.3	Tip	15.6	2.2	13.4	333	1302.4
9/7/2010 14:28	37.0	Tip	15.6	2.2	13.4	330	1305.4
9/7/2010 14:30	36.7	Tip	15.6	2.2	13.4	327	1293.4
9/7/2010 14:31	37.0	Tip	15.6	2.2	13.5	336	1314.4
9/7/2010 14:33	37.3	Tip	15.6	2.2	13.5	336	1319.2
9/7/2010 14:35	37.2	Tip	15.6	2.2	13.4	333	1317.4
9/7/2010 14:36	37.1	Tip	15.7	2.2	13.5	333	1305.4
9/7/2010 14:38	36.9	Tip	15.7	2.2	13.5	330	1299.2
9/7/2010 14:40	36.8	Tip	15.6	2.2	13.4	327	1290.4
9/7/2010 14:41	36.3	Tip	15.6	2.2	13.4	330	1302.4
9/7/2010 14:43	36.7	Tip	15.6	2.2	13.4	333	1299.4
9/7/2010 14:45	36.8	Tip	15.6	2.2	13.4	330	1299.7
9/7/2010 14:46	36.6	Tip	15.6	2.2	13.4	330	1302.9
9/7/2010 14:48	36.9	Tip	15.6	2.2	13.4	327	1293.9
9/7/2010 14:50	36.5	Tip	15.6	2.2	13.4	324	1284.7
9/7/2010 14:51	36.9	Tip	15.6	2.2	13.4	330	1290.4

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/7/2010 14:53	36.6	Tip	15.7	2.2	13.5	327	1293.2
9/7/2010 14:55	37.3	Tip	15.7	2.2	13.5	333	1305.0
9/7/2010 14:56	36.6	Tip	15.7	2.2	13.5	333	1299.0
9/7/2010 14:58	36.9	Tip	15.7	2.2	13.5	333	1304.7
9/7/2010 15:00	37.2	Tip	15.7	2.2	13.5	330	1302.0
9/7/2010 15:01	36.6	Tip	15.7	2.2	13.5	330	1296.0
9/7/2010 15:03	36.4	Tip	15.6	2.2	13.4	327	1287.4
9/7/2010 15:05	36.2	Tip	15.6	2.2	13.4	327	1290.7
9/7/2010 15:06	35.9	Tip	15.6	2.2	13.4	327	1290.7
9/7/2010 15:08	36.1	Tip	15.6	2.2	13.4	324	1284.9
9/7/2010 15:10	36.2	Tip	15.6	2.2	13.4	324	1282.9
9/7/2010 15:11	36.8	Tip	15.6	2.2	13.4	330	1299.9
9/7/2010 15:13	36.8	Tip	15.6	2.2	13.4	330	1305.9
9/7/2010 15:15	36.5	Tip	15.6	2.2	13.4	333	1299.9
9/7/2010 15:16	36.6	Tip	15.6	2.2	13.4	327	1297.2
9/7/2010 15:18	36.2	Tip	15.6	2.2	13.4	324	1285.6
9/7/2010 15:20	36.3	Tip	15.6	2.2	13.4	327	1291.9
9/7/2010 15:21	36.8	Tip	15.6	2.2	13.4	327	1297.9
9/7/2010 15:23	36.5	Tip	15.6	2.2	13.4	327	1291.9
9/7/2010 15:25	36.8	Tip	15.6	2.3	13.4	333	1301.4
9/7/2010 15:26	36.9	Tip	15.6	2.3	13.4	330	1301.4
9/7/2010 15:28	36.7	Tip	15.6	2.3	13.4	330	1301.6
9/7/2010 15:30	36.8	Tip	15.6	2.2	13.4	330	1304.4
9/7/2010 15:31	36.4	Tip	15.6	2.2	13.4	330	1304.6
9/7/2010 15:33	36.4	Tip	15.6	2.2	13.4	327	1295.4
9/7/2010 15:35	36.4	Tip	15.6	2.2	13.4	330	1295.1
9/7/2010 15:36	36.2	Tip	15.6	2.2	13.4	327	1284.4
9/7/2010 15:38	36.1	Tip	15.6	2.2	13.4	322	1274.4
9/7/2010 15:40	36.1	Tip	15.6	2.2	13.4	322	1277.4
9/7/2010 15:41	35.6	Tip	15.6	2.2	13.4	319	1268.4
9/7/2010 15:43	35.7	Tip	15.6	2.2	13.4	322	1271.6
9/7/2010 15:45	36.1	Tip	15.6	2.2	13.4	324	1279.4
9/7/2010 15:46	35.8	Tip	15.6	2.2	13.4	324	1284.4
9/7/2010 15:48	35.7	Tip	15.6	2.2	13.4	322	1271.1
9/7/2010 15:50	36.3	Tip	15.6	2.2	13.4	327	1283.9
9/7/2010 15:51	36.3	Tip	15.6	2.2	13.4	324	1281.9
9/7/2010 15:53	36.4	Tip	15.6	2.2	13.4	322	1276.6

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/7/2010 15:55	36.3	Tip	15.6	2.2	13.4	324	1285.4
9/7/2010 15:56	36.8	Tip	15.6	2.2	13.4	330	1291.4
9/7/2010 15:58	36.9	Tip	15.6	2.2	13.4	327	1291.2
9/7/2010 16:00	36.1	Tip	15.6	2.2	13.4	327	1288.2
9/7/2010 16:01	36.5	Tip	15.6	2.2	13.4	330	1294.2
9/7/2010 16:03	37.2	Tip	15.6	2.2	13.4	336	1309.6
9/7/2010 16:05	36.9	Tip	15.6	2.3	13.4	330	1304.4
9/7/2010 16:06	36.1	Tip	15.6	2.3	13.3	324	1284.8
9/7/2010 16:08	36.5	Tip	15.6	2.3	13.3	327	1290.1
9/7/2010 16:10	36.1	Tip	15.6	2.3	13.3	322	1285.1
9/7/2010 16:11	36.4	Tip	15.6	2.3	13.3	322	1278.1
9/7/2010 16:13	36.0	Tip	15.6	2.3	13.3	322	1271.8
9/7/2010 16:15	35.9	Tip	15.6	2.3	13.4	322	1277.6
9/7/2010 16:16	36.4	Tip	15.6	2.3	13.4	327	1290.4
9/7/2010 16:18	35.9	Tip	15.6	2.3	13.4	324	1279.1
9/7/2010 16:20	36.3	Tip	15.6	2.2	13.4	327	1283.6
9/7/2010 16:21	36.5	Tip	15.6	2.2	13.4	330	1291.6
9/7/2010 16:23	36.5	Tip	15.6	2.2	13.4	330	1300.4
9/7/2010 16:25	36.5	Tip	15.6	2.2	13.4	333	1303.6
9/7/2010 16:26	36.5	Tip	15.6	2.2	13.4	330	1294.6
9/7/2010 16:28	36.5	Tip	15.6	2.2	13.4	333	1301.1
9/7/2010 16:30	36.4	Tip	15.6	2.2	13.4	330	1298.4
9/7/2010 16:31	36.8	Tip	15.6	2.2	13.3	336	1313.6
9/7/2010 16:33	37.1	Tip	15.6	2.2	13.3	336	1317.1
9/7/2010 16:35	36.9	Tip	15.6	2.2	13.3	330	1302.1
9/7/2010 16:36	37.1	Tip	15.6	2.2	13.3	333	1311.1
9/7/2010 16:38	37.0	Tip	15.6	2.2	13.3	333	1310.8
9/7/2010 16:40	36.8	Tip	15.6	2.2	13.4	330	1295.6
9/7/2010 16:41	36.7	Tip	15.6	2.2	13.4	333	1310.6
9/7/2010 16:43	37.0	Tip	15.6	2.2	13.4	330	1304.4
9/7/2010 16:45	36.4	Tip	15.6	2.2	13.4	330	1310.1
9/7/2010 16:46	36.7	Tip	15.6	2.2	13.4	333	1309.9
9/7/2010 16:48	36.1	Tip	15.6	2.2	13.4	330	1297.9
9/7/2010 16:50	36.4	Tip	15.6	2.2	13.4	330	1298.4
9/7/2010 16:51	36.8	Tip	15.6	2.2	13.4	330	1301.6
9/7/2010 16:53	37.1	Tip	15.6	2.2	13.4	336	1313.6
9/7/2010 16:55	36.5	Tip	15.6	2.2	13.3	327	1295.8

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/7/2010 16:56	36.6	Tip	15.6	2.2	13.3	327	1295.8
9/7/2010 16:58	36.5	Tip	15.6	2.2	13.3	327	1289.8
9/7/2010 17:00	36.3	Tip	15.6	2.2	13.3	330	1301.8
9/7/2010 17:01	36.5	Tip	15.6	2.2	13.3	330	1298.8
9/7/2010 17:03	36.4	Tip	15.6	2.2	13.3	324	1286.8
9/7/2010 17:05	36.9	Tip	15.6	2.2	13.3	333	1307.8
9/7/2010 17:06	36.9	Tip	15.6	2.2	13.3	333	1307.8
9/7/2010 17:08	36.7	Tip	15.6	2.2	13.3	333	1304.8
9/7/2010 17:10	37.2	Tip	15.6	2.2	13.3	336	1313.8
9/7/2010 17:11	37.4	Tip	15.6	2.3	13.3	338	1322.6
9/7/2010 17:13	37.5	Tip	15.6	2.3	13.4	333	1316.6
9/7/2010 17:15	36.9	Tip	15.6	2.3	13.4	336	1310.4
9/7/2010 17:16	36.6	Tip	15.6	2.3	13.4	330	1298.4
9/7/2010 17:18	36.7	Tip	15.6	2.3	13.4	327	1298.1
9/7/2010 17:20	35.9	Tip	15.6	2.3	13.4	324	1284.1
9/7/2010 17:21	36.1	Tip	15.6	2.3	13.4	330	1292.4
9/7/2010 17:23	35.8	Tip	15.6	2.3	13.4	324	1282.6
9/7/2010 17:25	36.0	Tip	15.6	2.3	13.4	327	1292.6
9/7/2010 17:26	36.1	Tip	15.6	2.3	13.3	324	1284.8
9/7/2010 17:28	36.5	Tip	15.6	2.3	13.3	327	1286.8
9/7/2010 17:30	36.4	Tip	15.6	2.3	13.3	327	1292.8
9/7/2010 17:31	36.5	Tip	15.6	2.3	13.3	327	1293.1
9/7/2010 17:33	36.1	Tip	15.6	2.3	13.3	327	1286.8
9/7/2010 17:35	36.6	Tip	15.6	2.3	13.4	330	1295.6
9/7/2010 17:36	36.4	Tip	15.6	2.3	13.4	327	1289.6
9/7/2010 17:38	36.4	Tip	15.6	2.3	13.4	327	1289.6
9/7/2010 17:40	36.4	Tip	15.6	2.3	13.4	327	1292.6
9/7/2010 17:41	36.6	Tip	15.6	2.3	13.3	333	1301.8
9/7/2010 17:43	36.5	Tip	15.6	2.3	13.3	330	1301.8
9/7/2010 17:45	36.7	Tip	15.6	2.3	13.3	333	1308.1
9/7/2010 17:46	36.7	Tip	15.6	2.3	13.3	330	1308.6
9/7/2010 17:48	36.0	Tip	15.6	2.3	13.3	324	1287.6
9/7/2010 17:50	35.8	Tip	15.6	2.3	13.3	324	1285.6
9/7/2010 17:51	36.2	Tip	15.6	2.3	13.3	327	1293.8
9/7/2010 17:53	35.9	Tip	15.6	2.3	13.3	324	1285.8
9/7/2010 17:55	35.2	Tip	15.6	2.3	13.3	327	1293.8
9/7/2010 17:56	36.1	Tip	15.6	2.3	13.3	324	1287.8

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/7/2010 17:58	35.9	Tip	15.6	2.3	13.3	324	1285.6
9/7/2010 18:00	35.6	Tip	15.6	2.3	13.3	322	1275.6
9/7/2010 18:01	35.4	Tip	15.6	2.3	13.3	319	1269.6
9/7/2010 18:03	35.7	Tip	15.6	2.3	13.3	319	1269.3
9/7/2010 18:05	35.7	Tip	15.6	2.3	13.3	322	1278.3
9/7/2010 18:06	36.0	Tip	15.6	2.3	13.3	324	1278.3
9/7/2010 18:08	36.2	Tip	15.6	2.3	13.3	327	1293.6
9/7/2010 18:45	37.0	control	15.6	2.3	13.3	338	1328.3
9/7/2010 18:46	36.9	control	15.6	2.3	13.3	336	1318.3
9/7/2010 18:48	37.3	control	15.6	2.3	13.3	336	1321.3
9/7/2010 18:50	37.1	control	15.6	2.3	13.3	336	1321.3
9/8/2010 14:46	30.8	control	15.5	4.0	11.5	336	1430.0
9/8/2010 14:48	30.6	control	15.5	4.0	11.5	336	1424.0
9/8/2010 14:50	30.5	control	15.5	4.0	11.5	333	1418.0
9/8/2010 14:51	30.6	control	15.5	4.0	11.5	338	1430.0
9/8/2010 14:53	30.5	control	15.5	4.0	11.5	333	1418.0
9/8/2010 14:55	30.6	control	15.5	4.0	11.5	336	1430.0
9/8/2010 14:56	30.6	control	15.5	4.0	11.6	336	1430.0
9/8/2010 14:58	30.5	control	15.5	4.0	11.5	333	1418.0
9/8/2010 15:00	30.9	control	15.5	4.0	11.6	341	1443.0
9/8/2010 15:01	31.2	control	15.5	4.0	11.6	344	1462.0
9/8/2010 15:03	31.2	control	15.5	4.0	11.6	344	1452.0
9/8/2010 15:05	30.9	control	15.5	4.0	11.6	341	1449.0
9/8/2010 15:06	31.0	control	15.5	4.0	11.6	338	1446.0
9/8/2010 15:08	31.3	control	15.5	4.0	11.6	341	1452.0
9/8/2010 15:10	31.0	control	15.5	4.0	11.6	344	1459.0
9/8/2010 15:11	31.4	control	15.5	4.0	11.6	344	1457.0
9/8/2010 15:13	31.2	control	15.5	4.0	11.6	341	1446.0
9/8/2010 15:15	31.3	control	15.6	4.0	11.6	341	1462.0
9/8/2010 15:16	31.1	control	15.5	4.0	11.6	336	1440.0
9/8/2010 15:18	31.0	control	15.5	3.9	11.6	336	1418.0
9/8/2010 15:20	30.9	control	15.5	3.9	11.6	333	1415.0
9/8/2010 15:21	30.8	control	15.5	3.9	11.6	336	1412.0
9/8/2010 15:23	30.6	control	15.6	3.9	11.6	333	1424.0
9/8/2010 15:25	31.0	control	15.6	3.9	11.6	333	1427.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/8/2010 15:26	31.0	control	15.6	3.9	11.6	333	1412.0
9/8/2010 15:28	31.0	control	15.6	3.9	11.6	336	1427.0
9/8/2010 16:08	31.0	mid	15.6	3.9	11.7	333	1418.0
9/8/2010 16:10	31.3	mid	15.6	3.9	11.7	336	1418.0
9/8/2010 16:11	31.1	mid	15.6	3.9	11.7	336	1424.0
9/8/2010 16:13	30.9	mid	15.6	3.9	11.7	330	1412.0
9/8/2010 16:15	31.1	mid	15.6	3.9	11.7	336	1430.0
9/8/2010 16:16	31.4	mid	15.6	3.8	11.7	338	1440.0
9/8/2010 16:18	31.1	mid	15.6	3.8	11.7	333	1418.0
9/8/2010 16:20	31.6	mid	15.5	3.8	11.7	336	1440.0
9/8/2010 16:21	31.5	mid	15.5	3.8	11.7	336	1430.0
9/8/2010 16:23	31.4	mid	15.5	3.8	11.7	336	1430.0
9/8/2010 16:25	31.0	mid	15.5	3.8	11.7	338	1440.0
9/8/2010 16:26	31.1	mid	15.5	3.8	11.7	338	1432.0
9/8/2010 16:28	31.3	mid	15.5	3.8	11.7	333	1418.0
9/8/2010 16:30	31.3	mid	15.5	3.8	11.7	333	1433.0
9/8/2010 16:31	31.5	mid	15.5	3.8	11.7	341	1449.0
9/8/2010 16:33	31.4	mid	15.5	3.8	11.7	338	1443.0
9/8/2010 16:35	31.6	mid	15.5	3.8	11.7	336	1440.0
9/8/2010 16:36	31.2	mid	15.5	3.8	11.7	341	1438.0
9/8/2010 16:38	31.4	mid	15.5	3.8	11.7	336	1437.0
9/8/2010 16:40	31.3	mid	15.5	3.8	11.7	333	1424.0
9/8/2010 16:41	31.1	mid	15.5	3.8	11.7	336	1421.0
9/8/2010 16:43	31.3	mid	15.5	3.8	11.7	336	1421.0
9/8/2010 16:45	31.3	mid	15.5	3.8	11.7	338	1432.0
9/8/2010 16:46	31.6	mid	15.5	3.8	11.7	341	1449.0
9/8/2010 16:48	31.4	mid	15.5	3.8	11.7	338	1446.0
9/8/2010 16:50	31.2	mid	15.5	3.8	11.7	338	1452.0
9/8/2010 16:51	31.4	mid	15.5	3.8	11.7	341	1446.0
9/8/2010 16:53	31.2	mid	15.5	3.8	11.7	341	1443.0
9/8/2010 16:55	31.2	mid	15.5	3.8	11.7	338	1443.0
9/8/2010 16:56	31.8	mid	15.5	3.8	11.7	338	1440.0
9/8/2010 16:58	31.5	mid	15.5	3.8	11.7	338	1440.0
9/8/2010 17:00	31.4	mid	15.5	3.8	11.7	338	1435.0
9/8/2010 17:01	31.4	mid	15.5	3.8	11.7	338	1432.0
9/8/2010 17:03	31.5	mid	15.5	3.8	11.7	341	1446.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/8/2010 17:05	31.7	mid	15.5	3.8	11.7	347	1462.0
9/8/2010 17:06	31.6	mid	15.5	3.8	11.7	341	1452.0
9/8/2010 17:08	31.6	mid	15.5	3.8	11.7	336	1435.0
9/8/2010 17:10	31.6	mid	15.5	3.8	11.7	338	1440.0
9/8/2010 17:11	31.4	mid	15.5	3.8	11.7	338	1435.0
9/8/2010 17:13	31.2	mid	15.5	3.8	11.7	336	1424.0
9/8/2010 17:15	31.3	mid	15.5	3.8	11.7	336	1430.0
9/8/2010 17:16	31.7	mid	15.5	3.8	11.7	338	1444.0
9/8/2010 17:18	31.5	mid	15.5	3.8	11.7	341	1452.0
9/8/2010 17:20	31.9	mid	15.5	3.8	11.7	341	1443.0
9/8/2010 17:21	32.0	mid	15.5	3.8	11.8	344	1455.0
9/8/2010 17:23	31.8	mid	15.5	3.8	11.8	344	1462.0
9/8/2010 17:25	32.0	mid	15.5	3.8	11.8	341	1452.0
9/8/2010 17:26	31.9	mid	15.5	3.8	11.8	338	1440.0
9/8/2010 17:28	31.4	mid	15.5	3.8	11.8	336	1430.0
9/8/2010 17:30	31.8	mid	15.5	3.8	11.8	338	1449.0
9/8/2010 17:31	31.7	mid	15.5	3.8	11.8	338	1440.0
9/8/2010 17:33	31.7	mid	15.5	3.8	11.8	336	1435.0
9/8/2010 17:35	31.5	mid	15.5	3.7	11.8	333	1430.0
9/8/2010 17:36	31.4	mid	15.5	3.7	11.8	336	1424.0
9/8/2010 17:38	31.3	mid	15.5	3.7	11.8	338	1427.0
9/8/2010 17:40	31.0	mid	15.5	3.7	11.8	330	1415.0
9/8/2010 17:41	31.4	mid	15.5	3.7	11.8	338	1440.0
9/8/2010 17:43	31.6	mid	15.5	3.8	11.8	338	1440.0
9/8/2010 17:45	31.1	mid	15.5	3.8	11.8	338	1440.0
9/8/2010 17:46	31.7	mid	15.5	3.8	11.8	338	1435.0
9/8/2010 17:48	31.7	mid	15.5	3.8	11.8	341	1446.0
9/8/2010 17:50	31.6	mid	15.5	3.7	11.8	341	1446.0
9/8/2010 17:51	31.7	mid	15.5	3.7	11.8	336	1440.0
9/8/2010 17:53	31.7	mid	15.5	3.7	11.8	341	1440.0
9/8/2010 17:55	31.6	mid	15.5	3.7	11.8	341	1446.0
9/8/2010 17:56	31.7	mid	15.5	3.7	11.8	338	1443.0
9/8/2010 17:58	31.5	mid	15.5	3.7	11.8	330	1406.0
9/8/2010 18:00	31.2	mid	15.5	3.7	11.8	333	1398.0
9/8/2010 18:01	31.4	mid	15.5	3.7	11.8	338	1424.0
9/8/2010 18:03	31.9	mid	15.5	3.7	11.8	341	1441.0
9/8/2010 18:05	32.2	mid	15.5	3.7	11.8	341	1443.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/8/2010 18:06	31.8	mid	15.5	3.7	11.8	341	1443.0
9/8/2010 18:08	32.0	mid	15.5	3.7	11.8	341	1432.0
9/8/2010 18:10	32.0	mid	15.5	3.7	11.9	341	1438.0
9/8/2010 18:11	31.8	mid	15.5	3.7	11.9	336	1430.0
9/8/2010 18:13	31.4	mid	15.5	3.7	11.9	336	1418.0
9/8/2010 18:15	31.6	mid	15.5	3.7	11.9	338	1429.0
9/8/2010 18:16	32.0	mid	15.5	3.7	11.9	341	1441.0
9/8/2010 18:18	31.8	mid	15.5	3.7	11.9	344	1449.0
9/8/2010 18:20	31.8	mid	15.5	3.7	11.9	338	1437.0
9/8/2010 18:21	32.2	mid	15.5	3.7	11.8	344	1454.0
9/8/2010 18:23	32.6	mid	15.5	3.7	11.8	347	1462.0
9/8/2010 18:25	32.1	mid	15.5	3.7	11.9	344	1457.0
9/8/2010 18:26	32.2	mid	15.5	3.7	11.9	341	1452.0
9/8/2010 18:28	32.4	mid	15.5	3.7	11.9	341	1446.0
9/8/2010 18:30	32.2	mid	15.5	3.7	11.9	341	1449.0
9/8/2010 18:31	32.0	mid	15.5	3.7	11.9	344	1452.0
9/8/2010 18:33	32.3	mid	15.5	3.6	11.9	341	1449.0
9/8/2010 18:35	32.5	mid	15.5	3.6	11.9	341	1443.0
9/8/2010 18:36	32.2	mid	15.6	3.6	11.9	341	1437.0
9/8/2010 18:38	32.5	mid	15.6	3.6	11.9	344	1452.0
9/8/2010 18:40	32.6	mid	15.6	3.6	11.9	344	1455.0
9/8/2010 18:41	32.4	mid	15.6	3.6	11.9	341	1443.0
9/9/2010 9:28	36.6	mid	15.8	2.3	13.5	330	1278.0
9/9/2010 9:30	36.6	mid	15.8	2.3	13.5	333	1281.0
9/9/2010 9:31	36.3	mid	15.8	2.3	13.4	330	1269.0
9/9/2010 9:33	36.7	mid	15.8	2.3	13.4	330	1269.0
9/9/2010 9:35	36.7	mid	15.8	2.3	13.4	330	1272.0
9/9/2010 9:36	37.0	mid	15.8	2.3	13.4	333	1281.0
9/9/2010 9:38	36.3	mid	15.8	2.3	13.4	327	1261.0
9/9/2010 9:40	37.2	mid	15.8	2.3	13.4	333	1293.0
9/9/2010 9:41	36.9	mid	15.8	2.3	13.4	333	1278.0
9/9/2010 9:43	36.8	mid	15.8	2.3	13.4	330	1293.0
9/9/2010 9:45	36.4	mid	15.8	2.3	13.4	330	1284.0
9/9/2010 9:46	36.9	mid	15.8	2.3	13.4	330	1284.0
9/9/2010 9:48	36.9	mid	15.8	2.3	13.4	333	1295.0
9/9/2010 9:50	35.9	mid	15.8	2.3	13.4	327	1281.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/9/2010 9:51	36.7	mid	15.8	2.3	13.4	333	1292.0
9/9/2010 9:53	36.5	mid	15.8	2.3	13.4	330	1289.0
9/9/2010 9:55	36.7	mid	15.8	2.4	13.4	330	1295.0
9/9/2010 9:56	36.7	mid	15.7	2.4	13.4	330	1289.0
9/9/2010 9:58	35.9	mid	15.7	2.4	13.4	322	1264.0
9/9/2010 10:00	35.8	mid	15.7	2.4	13.4	319	1251.0
9/9/2010 10:01	35.7	mid	15.8	2.4	13.4	322	1250.0
9/9/2010 10:03	36.2	mid	15.8	2.4	13.4	324	1261.0
9/9/2010 10:05	36.4	mid	15.8	2.3	13.4	324	1266.0
9/9/2010 10:06	36.3	mid	15.8	2.3	13.4	322	1250.0
9/9/2010 10:08	35.8	mid	15.8	2.3	13.4	322	1256.0
9/9/2010 10:10	36.2	mid	15.8	2.3	13.4	322	1264.0
9/9/2010 10:11	36.1	mid	15.8	2.3	13.4	324	1264.0
9/9/2010 10:13	36.2	mid	15.8	2.3	13.4	324	1259.0
9/9/2010 10:15	35.8	mid	15.8	2.3	13.4	324	1261.0
9/9/2010 10:16	36.1	mid	15.8	2.3	13.4	324	1266.0
9/9/2010 10:18	36.1	mid	15.8	2.3	13.4	324	1256.0
9/9/2010 10:20	36.4	mid	15.8	2.3	13.4	324	1272.0
9/9/2010 10:21	36.5	mid	15.8	2.3	13.4	327	1275.0
9/9/2010 10:23	36.2	mid	15.8	2.3	13.4	327	1272.0
9/9/2010 10:25	36.2	mid	15.8	2.3	13.4	330	1289.0
9/9/2010 10:26	36.3	mid	15.8	2.3	13.4	327	1278.0
9/9/2010 10:28	36.2	mid	15.8	2.4	13.4	330	1284.0
9/9/2010 10:30	36.0	mid	15.7	2.4	13.4	324	1266.0
9/9/2010 10:31	36.5	mid	15.7	2.4	13.4	327	1272.0
9/9/2010 10:33	36.2	mid	15.7	2.4	13.4	327	1272.0
9/9/2010 10:35	36.7	mid	15.7	2.4	13.4	333	1290.0
9/9/2010 10:36	36.9	mid	15.8	2.4	13.4	336	1298.0
9/9/2010 10:38	36.4	mid	15.8	2.4	13.4	330	1278.0
9/9/2010 10:40	36.6	mid	15.8	2.4	13.4	330	1295.0
9/9/2010 10:41	36.7	mid	15.8	2.4	13.4	330	1286.0
9/9/2010 10:43	36.9	mid	15.8	2.4	13.4	333	1289.0
9/9/2010 10:45	36.4	mid	15.8	2.4	13.4	330	1284.0
9/9/2010 10:46	36.5	mid	15.8	2.4	13.4	327	1275.0
9/9/2010 10:48	36.6	mid	15.8	2.4	13.4	327	1278.0
9/9/2010 10:50	36.0	mid	15.8	2.4	13.4	327	1275.0
9/9/2010 10:51	35.8	mid	15.8	2.4	13.4	324	1261.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/9/2010 10:53	35.6	mid	15.8	2.4	13.4	324	1261.0
9/9/2010 10:55	35.9	mid	15.8	2.4	13.4	327	1284.0
9/9/2010 10:56	36.1	mid	15.8	2.4	13.4	324	1264.0
9/9/2010 10:58	35.8	mid	15.8	2.4	13.4	327	1267.0
9/9/2010 11:00	36.2	mid	15.8	2.4	13.4	327	1269.0
9/9/2010 11:01	36.1	mid	15.8	2.4	13.4	327	1284.0
9/9/2010 11:03	36.0	mid	15.8	2.4	13.4	330	1284.0
9/9/2010 11:05	36.4	mid	15.8	2.4	13.4	330	1284.0
9/9/2010 11:06	36.0	mid	15.8	2.4	13.4	330	1278.0
9/9/2010 11:08	36.0	mid	15.8	2.4	13.3	327	1278.0
9/9/2010 11:10	35.8	mid	15.8	2.4	13.3	327	1269.0
9/9/2010 11:11	36.1	mid	15.8	2.4	13.3	330	1284.0
9/9/2010 11:13	36.1	mid	15.8	2.4	13.3	327	1278.0
9/9/2010 11:15	36.1	mid	15.8	2.4	13.3	324	1275.0
9/9/2010 11:16	36.5	mid	15.8	2.4	13.3	330	1287.0
9/9/2010 11:18	36.0	mid	15.8	2.4	13.3	327	1266.0
9/9/2010 11:20	36.4	mid	15.8	2.5	13.3	330	1287.0
9/9/2010 11:21	36.1	mid	15.8	2.5	13.3	330	1284.0
9/9/2010 11:23	36.0	mid	15.8	2.5	13.3	327	1278.0
9/9/2010 11:25	35.9	mid	15.8	2.5	13.3	330	1275.0
9/9/2010 11:26	36.3	mid	15.8	2.5	13.3	330	1281.0
9/9/2010 11:28	36.3	mid	15.8	2.5	13.3	330	1284.0
9/9/2010 11:30	36.4	mid	15.8	2.5	13.3	327	1278.0
9/9/2010 11:31	36.2	mid	15.8	2.5	13.3	330	1284.0
9/9/2010 11:33	36.1	mid	15.8	2.5	13.3	330	1278.0
9/9/2010 11:35	36.4	mid	15.8	2.5	13.3	333	1295.0
9/9/2010 11:36	36.5	mid	15.8	2.5	13.3	330	1286.0
9/9/2010 11:38	36.3	mid	15.8	2.5	13.3	330	1286.0
9/9/2010 11:40	36.1	mid	15.8	2.5	13.3	330	1286.0
9/9/2010 11:41	36.1	mid	15.8	2.5	13.3	330	1284.0
9/9/2010 11:43	35.9	mid	15.8	2.5	13.3	330	1284.0
9/9/2010 11:45	36.1	mid	15.8	2.5	13.3	327	1284.0
9/9/2010 11:46	35.5	mid	15.8	2.5	13.3	330	1278.0
9/9/2010 11:48	35.9	mid	15.8	2.5	13.3	327	1278.0
9/9/2010 11:50	35.7	mid	15.8	2.5	13.2	327	1272.0
9/9/2010 11:51	36.5	mid	15.8	2.6	13.2	333	1292.0
9/9/2010 11:53	35.8	mid	15.8	2.6	13.2	327	1275.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/9/2010 11:55	36.1	mid	15.8	2.6	13.2	330	1284.0
9/9/2010 11:56	36.3	mid	15.8	2.6	13.2	330	1308.3
9/9/2010 11:58	36.4	mid	15.8	2.6	13.2	332	1308.3
9/9/2010 12:00	35.7	mid	15.8	2.6	13.2	332	1308.3
9/9/2010 12:01	36.8	mid	15.8	2.6	13.2	338	1308.3
9/9/2010 12:03	36.4	mid	15.8	2.6	13.2	332	1309.2
9/9/2010 12:05	36.2	mid	15.8	2.6	13.2	332	1309.2
9/9/2010 12:06	36.3	mid	15.8	2.6	13.2	332	1309.2
9/9/2010 12:08	36.3	mid	15.8	2.6	13.2	332	1310.1
9/9/2010 12:10	36.3	mid	15.8	2.6	13.2	332	1310.1
9/9/2010 12:11	36.5	mid	15.8	2.6	13.2	338	1311.1
9/9/2010 12:13	36.4	mid	15.7	2.6	13.2	332	1313.0
9/9/2010 12:15	36.1	mid	15.7	2.6	13.2	332	1313.9
9/9/2010 12:16	36.3	mid	15.7	2.6	13.2	332	1313.9
9/9/2010 12:18	35.7	mid	15.7	2.6	13.2	332	1313.9
9/9/2010 12:20	36.1	mid	15.8	2.6	13.2	333	1312.0
9/9/2010 12:21	36.0	mid	15.8	2.6	13.2	333	1313.0
9/9/2010 12:23	35.9	mid	15.8	2.6	13.2	333	1312.0
9/9/2010 12:25	36.0	mid	15.8	2.6	13.2	333	1312.0
9/9/2010 12:26	36.3	mid	15.8	2.6	13.2	333	1312.0
9/9/2010 12:28	35.7	mid	15.8	2.6	13.2	333	1313.9
9/9/2010 12:30	35.5	mid	15.8	2.6	13.1	327	1314.8
9/9/2010 12:31	35.7	mid	15.8	2.6	13.1	333	1314.8
9/9/2010 12:33	36.6	mid	15.8	2.6	13.1	333	1316.7
9/9/2010 12:35	36.4	mid	15.7	2.7	13.1	333	1319.5
9/9/2010 12:36	36.4	mid	15.7	2.7	13.1	335	1320.5
9/9/2010 12:38	36.5	mid	15.7	2.7	13.1	335	1320.5
9/9/2010 12:40	36.4	mid	15.8	2.7	13.1	335	1320.5
9/9/2010 12:41	36.4	mid	15.8	2.7	13.1	335	1320.5
9/9/2010 12:43	35.9	mid	15.8	2.7	13.1	335	1321.4
9/9/2010 12:45	36.1	mid	15.8	2.7	13.1	335	1320.5
9/9/2010 12:46	35.6	mid	15.8	2.7	13.1	335	1320.5
9/9/2010 12:48	35.6	mid	15.8	2.7	13.1	335	1319.5
9/9/2010 12:50	35.9	mid	15.8	2.7	13.1	335	1318.6
9/9/2010 12:51	36.0	mid	15.8	2.7	13.1	335	1318.6
9/9/2010 12:53	36.1	mid	15.8	2.7	13.1	335	1318.6
9/9/2010 12:55	36.0	mid	15.7	2.7	13.1	335	1320.5

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/9/2010 12:56	36.2	mid	15.7	2.7	13.1	335	1321.4
9/9/2010 12:58	36.1	mid	15.7	2.7	13.1	335	1322.4
9/9/2010 13:00	36.3	mid	15.7	2.7	13.1	335	1322.4
9/9/2010 13:01	37.0	mid	15.7	2.7	13.1	347	1322.4
9/9/2010 13:03	37.3	mid	15.7	2.7	13.1	352	1322.4
9/9/2010 13:05	37.5	mid	15.8	2.7	13.1	350	1323.3
9/9/2010 13:06	37.3	mid	15.8	2.7	13.1	347	1323.3
9/9/2010 13:08	36.5	mid	15.8	2.7	13.1	347	1322.4
9/9/2010 13:10	37.0	mid	15.8	2.7	13.1	344	1321.4
9/9/2010 13:11	36.9	mid	15.8	2.7	13.1	344	1321.4
9/9/2010 13:13	36.5	mid	15.8	2.7	13.1	341	1321.4
9/9/2010 13:15	36.3	mid	15.8	2.7	13.1	335	1321.4
9/9/2010 13:16	36.3	mid	15.8	2.7	13.1	335	1321.4
9/9/2010 13:18	36.1	mid	15.8	2.7	13.1	335	1321.4
9/9/2010 13:20	36.2	mid	15.8	2.7	13.1	335	1319.5
9/9/2010 13:21	36.0	mid	15.8	2.7	13.1	335	1319.5
9/9/2010 13:23	36.0	mid	15.8	2.7	13.1	335	1322.4
9/9/2010 13:25	35.9	mid	15.8	2.7	13.1	335	1322.4
9/9/2010 13:26	35.8	mid	15.8	2.7	13.0	335	1323.3
9/9/2010 13:28	35.9	mid	15.8	2.7	13.0	336	1324.2
9/9/2010 13:30	35.8	mid	15.8	2.7	13.0	330	1312.0
9/9/2010 13:31	35.6	mid	15.8	2.7	13.0	336	1320.0
9/9/2010 13:33	36.2	mid	15.8	2.7	13.0	336	1326.0
9/9/2010 13:35	36.1	mid	15.7	2.7	13.0	333	1334.0
9/9/2010 13:36	35.8	mid	15.7	2.7	13.0	333	1306.0
9/9/2010 13:38	36.0	mid	15.7	2.7	13.0	333	1315.0
9/9/2010 13:40	35.9	mid	15.8	2.7	13.0	336	1323.0
9/9/2010 13:41	36.0	mid	15.8	2.7	13.0	338	1336.0
9/9/2010 13:43	35.9	mid	15.8	2.7	13.0	336	1329.0
9/9/2010 13:45	36.1	mid	15.8	2.7	13.0	336	1323.0
9/9/2010 13:46	36.0	mid	15.8	2.7	13.0	336	1326.0
9/9/2010 13:48	36.3	mid	15.8	2.7	13.0	341	1334.0
9/9/2010 13:50	36.1	mid	15.7	2.7	13.0	333	1323.0
9/9/2010 13:51	35.7	mid	15.7	2.7	13.0	336	1326.0
9/9/2010 13:53	36.1	mid	15.7	2.7	13.0	338	1334.0
9/9/2010 13:55	36.0	mid	15.7	2.7	13.0	336	1331.0
9/9/2010 13:56	36.0	mid	15.7	2.7	13.0	336	1328.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/9/2010 13:58	35.9	mid	15.7	2.7	13.0	338	1331.0
9/9/2010 14:00	36.2	mid	15.7	2.7	13.0	333	1331.0
9/9/2010 14:01	36.0	mid	15.7	2.7	13.0	341	1342.0
9/9/2010 14:03	36.3	mid	15.7	2.7	13.0	338	1345.0
9/9/2010 14:05	36.5	mid	15.8	2.7	13.0	338	1345.0
9/9/2010 14:06	36.1	mid	15.8	2.7	13.0	338	1334.0
9/9/2010 14:08	36.2	mid	15.8	2.7	13.0	338	1334.0
9/9/2010 14:10	36.0	mid	15.8	2.7	13.0	338	1334.0
9/9/2010 14:11	36.0	mid	15.8	2.7	13.0	338	1326.0
9/9/2010 14:13	35.8	mid	15.7	2.7	13.0	341	1329.0
9/9/2010 14:15	35.7	mid	15.7	2.7	13.0	336	1320.0
9/9/2010 14:16	36.1	mid	15.7	2.7	13.0	338	1331.0
9/9/2010 14:18	36.0	mid	15.7	2.7	13.0	336	1320.0
9/9/2010 14:20	35.7	mid	15.7	2.7	13.0	333	1317.0
9/9/2010 14:21	35.9	mid	15.7	2.7	13.0	330	1306.0
9/9/2010 14:23	35.3	mid	15.7	2.7	13.0	330	1306.0
9/9/2010 14:25	35.9	mid	15.7	2.7	13.0	333	1315.0
9/9/2010 14:26	35.7	mid	15.7	2.7	13.0	333	1309.0
9/9/2010 14:28	35.5	mid	15.7	2.7	13.0	333	1309.0
9/9/2010 14:30	35.7	mid	15.7	2.7	13.0	333	1312.0
9/9/2010 14:31	36.1	mid	15.7	2.7	13.0	341	1334.0
9/9/2010 14:33	36.3	mid	15.7	2.7	13.0	341	1334.0
9/9/2010 14:35	35.8	mid	15.7	2.8	13.0	336	1326.0
9/9/2010 14:36	36.2	mid	15.7	2.8	13.0	341	1326.0
9/9/2010 14:38	36.4	mid	15.7	2.8	13.0	338	1345.0
9/9/2010 14:40	36.2	mid	15.7	2.8	13.0	333	1320.0
9/9/2010 14:41	36.1	mid	15.7	2.8	13.0	338	1331.0
9/9/2010 14:43	35.8	mid	15.7	2.8	13.0	333	1320.0
9/9/2010 14:45	35.9	mid	15.7	2.8	13.0	333	1314.0
9/9/2010 14:46	36.3	mid	15.7	2.8	13.0	338	1329.0
9/9/2010 14:48	35.7	mid	15.7	2.8	13.0	330	1314.0
9/9/2010 14:50	35.5	mid	15.7	2.8	13.0	333	1309.0
9/9/2010 14:51	35.4	mid	15.7	2.7	13.0	333	1312.0
9/9/2010 14:53	35.9	mid	15.7	2.7	13.0	336	1320.0
9/9/2010 14:55	35.7	mid	15.7	2.7	13.0	336	1315.0
9/9/2010 14:56	35.3	mid	15.7	2.7	13.0	333	1312.0
9/9/2010 14:58	35.7	mid	15.7	2.7	13.0	333	1317.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/9/2010 15:00	35.7	mid	15.7	2.7	13.0	333	1317.0
9/9/2010 15:01	35.9	mid	15.7	2.7	13.0	338	1334.0
9/9/2010 15:23	36.2	control	15.7	2.8	13.0	341	1345.0
9/9/2010 15:25	36.3	control	15.7	2.8	13.0	341	1342.0
9/9/2010 15:26	35.8	control	15.7	2.8	13.0	336	1329.0
9/9/2010 15:28	35.4	control	15.7	2.8	13.0	336	1323.0
9/9/2010 15:30	35.8	control	15.7	2.8	13.0	336	1320.0
9/9/2010 15:31	35.7	control	15.7	2.8	13.0	336	1329.0
9/9/2010 15:33	35.7	control	15.7	2.8	13.0	336	1309.0
9/9/2010 15:35	36.2	control	15.7	2.8	13.0	338	1336.0
9/9/2010 15:36	35.9	control	15.7	2.8	13.0	336	1329.0
9/9/2010 15:38	35.6	control	15.7	2.8	13.0	330	1309.0
9/9/2010 15:40	35.6	control	15.7	2.8	13.0	330	1312.0
9/9/2010 15:41	35.8	control	15.7	2.7	13.0	336	1315.0
9/9/2010 15:43	35.6	control	15.7	2.7	13.0	330	1306.0
9/9/2010 15:45	35.9	control	15.7	2.7	13.0	338	1339.0
9/9/2010 15:46	35.6	control	15.7	2.8	13.0	336	1317.0
9/9/2010 15:48	35.8	control	15.7	2.8	13.0	336	1317.0
9/9/2010 15:50	35.9	control	15.7	2.8	13.0	336	1334.0
9/9/2010 15:51	35.7	control	15.7	2.8	13.0	336	1312.0
9/9/2010 15:53	35.3	control	15.7	2.8	13.0	333	1309.0
9/9/2010 15:55	35.7	control	15.7	2.8	13.0	333	1323.0
9/9/2010 15:56	36.0	control	15.7	2.8	12.9	336	1326.0
9/9/2010 15:58	35.8	control	15.7	2.8	12.9	336	1323.0
9/9/2010 16:00	35.9	control	15.7	2.8	13.0	330	1300.0
9/9/2010 16:01	35.8	control	15.7	2.8	13.0	338	1331.0
9/9/2010 16:03	36.0	control	15.7	2.8	13.0	338	1331.0
9/9/2010 16:05	35.8	control	15.7	2.8	13.0	338	1323.0
9/9/2010 16:06	35.6	control	15.7	2.8	13.0	338	1323.0
9/9/2010 16:08	36.0	control	15.7	2.8	13.0	341	1354.0
9/9/2010 16:10	35.8	control	15.7	2.8	13.0	341	1348.0
9/9/2010 16:11	36.0	control	15.7	2.8	13.0	338	1342.0
9/9/2010 16:13	35.8	control	15.7	2.8	13.0	338	1320.0
9/9/2010 16:15	35.6	control	15.7	2.8	12.9	333	1320.0
9/9/2010 16:16	35.9	control	15.7	2.8	12.9	338	1329.0
9/9/2010 16:18	35.0	control	15.7	2.8	12.9	333	1306.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/9/2010 16:20	35.6	control	15.7	2.8	12.9	330	1317.0
9/9/2010 16:21	35.8	control	15.7	2.8	12.9	333	1323.0
9/9/2010 16:23	36.1	control	15.7	2.8	13.0	336	1323.0
9/9/2010 16:25	36.2	control	15.7	2.8	13.0	338	1342.0
9/9/2010 16:26	35.8	control	15.7	2.8	13.0	336	1320.0
9/9/2010 16:28	35.7	control	15.7	2.8	13.0	333	1317.0
9/9/2010 16:30	35.5	control	15.7	2.8	13.0	330	1309.0
9/9/2010 16:31	35.9	control	15.7	2.8	13.0	338	1331.0
9/9/2010 16:33	36.1	control	15.7	2.8	13.0	341	1339.0
9/9/2010 16:35	36.0	control	15.7	2.8	13.0	338	1336.0
9/9/2010 16:36	36.1	control	15.7	2.8	13.0	338	1336.0
9/9/2010 16:38	36.1	control	15.7	2.8	13.0	338	1336.0
9/9/2010 16:40	35.9	control	15.7	2.8	13.0	333	1331.0
9/9/2010 16:41	35.7	control	15.7	2.8	13.0	336	1320.0
9/9/2010 16:43	35.3	control	15.7	2.8	13.0	333	1312.0
9/9/2010 16:45	35.9	control	15.7	2.8	13.0	338	1334.0
9/9/2010 16:46	36.4	control	15.7	2.8	13.0	341	1345.0
9/9/2010 16:48	35.9	control	15.7	2.8	12.9	338	1329.0
9/9/2010 16:50	35.8	control	15.7	2.8	12.9	333	1331.0
9/9/2010 16:51	36.2	control	15.7	2.8	12.9	338	1328.0
9/9/2010 16:53	35.9	control	15.7	2.8	12.9	338	1331.0
9/9/2010 16:55	35.7	control	15.7	2.8	12.9	333	1312.0
9/9/2010 16:56	35.6	control	15.7	2.8	12.9	336	1315.0
9/9/2010 16:58	35.7	control	15.7	2.8	12.9	333	1312.0
9/9/2010 17:00	35.0	control	15.7	2.8	13.0	330	1300.0
9/9/2010 17:01	35.8	control	15.7	2.8	13.0	333	1306.0
9/9/2010 17:03	35.8	control	15.7	2.8	13.0	336	1309.0
9/9/2010 17:05	35.7	control	15.7	2.7	13.0	336	1320.0
9/9/2010 17:06	35.8	control	15.7	2.7	13.0	336	1323.0
9/9/2010 17:08	35.7	control	15.7	2.7	13.0	336	1323.0
9/9/2010 17:10	35.8	control	15.7	2.7	13.0	336	1320.0
9/9/2010 17:11	35.7	control	15.7	2.7	13.0	341	1345.0
9/9/2010 17:13	36.3	control	15.7	2.7	13.0	341	1339.0
9/9/2010 17:15	36.0	control	15.7	2.7	13.0	336	1334.0
9/9/2010 17:16	36.1	control	15.7	2.8	13.0	338	1328.0
9/9/2010 17:18	36.0	control	15.7	2.8	13.0	341	1331.0
9/9/2010 17:20	35.8	control	15.7	2.8	13.0	333	1320.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/9/2010 17:21	36.0	control	15.7	2.8	13.0	336	1320.0
9/9/2010 17:23	35.5	control	15.7	2.8	13.0	333	1306.0
9/9/2010 17:25	35.6	control	15.7	2.8	13.0	336	1317.0
9/9/2010 17:26	36.0	control	15.7	2.7	13.0	338	1329.0
9/9/2010 17:28	35.6	control	15.7	2.7	13.0	336	1317.0
9/9/2010 17:30	35.5	control	15.7	2.7	13.0	333	1328.0
9/9/2010 17:31	35.8	control	15.7	2.7	13.0	330	1317.0
9/9/2010 17:33	36.1	control	15.7	2.7	13.0	336	1312.0
9/9/2010 17:35	35.8	control	15.7	2.7	13.0	333	1317.0
9/9/2010 17:36	35.9	control	15.7	2.7	13.0	336	1334.0
9/9/2010 17:38	35.8	control	15.7	2.7	13.0	336	1323.0
9/9/2010 17:40	35.8	control	15.7	2.7	13.0	330	1314.0
9/9/2010 17:41	35.8	control	15.7	2.7	13.0	336	1326.0
9/9/2010 17:43	35.9	control	15.7	2.7	13.0	338	1326.0
9/9/2010 17:45	36.1	control	15.7	2.7	13.0	336	1329.0
9/9/2010 17:46	35.6	control	15.7	2.7	13.0	336	1329.0
9/9/2010 17:48	36.2	control	15.7	2.7	13.0	338	1334.0
9/9/2010 17:50	35.6	control	15.7	2.7	13.0	336	1326.0
9/9/2010 17:51	36.3	control	15.7	2.7	13.0	338	1334.0
9/9/2010 17:53	36.2	control	15.7	2.7	13.0	338	1334.0
9/9/2010 17:55	36.3	control	15.7	2.7	13.0	338	1339.0
9/9/2010 17:56	36.2	control	15.7	2.7	13.0	338	1339.0
9/9/2010 17:58	36.2	control	15.7	2.7	13.0	338	1329.0
9/9/2010 18:00	35.5	control	15.7	2.8	12.9	330	1323.0
9/10/2010 9:00	36.2	Tip	15.4	1.9	13.6	322	1263.1
9/10/2010 9:01	36.5	Tip	15.5	1.9	13.6	324	1263.1
9/10/2010 9:03	36.1	Tip	15.5	1.9	13.6	322	1254.1
9/10/2010 9:05	35.8	Tip	15.5	1.9	13.6	322	1257.3
9/10/2010 9:06	36.3	Tip	15.5	1.9	13.6	322	1257.3
9/10/2010 9:08	36.2	Tip	15.5	1.9	13.6	322	1260.1
9/10/2010 9:10	36.5	Tip	15.4	1.9	13.6	322	1256.8
9/10/2010 9:11	36.5	Tip	15.4	1.9	13.6	324	1264.8
9/10/2010 9:13	36.5	Tip	15.4	1.9	13.6	327	1273.8
9/10/2010 9:15	36.8	Tip	15.4	1.9	13.6	330	1274.1
9/10/2010 9:16	36.9	Tip	15.4	1.9	13.6	330	1274.1
9/10/2010 9:18	36.9	Tip	15.4	1.9	13.6	330	1279.3

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/10/2010 9:20	37.2	Tip	15.4	1.9	13.6	330	1285.1
9/10/2010 9:21	37.1	Tip	15.4	1.9	13.6	333	1285.1
9/10/2010 9:23	37.0	Tip	15.4	1.9	13.6	327	1287.8
9/10/2010 9:25	36.9	Tip	15.5	1.9	13.6	327	1287.8
9/10/2010 9:26	36.9	Tip	15.5	1.9	13.6	330	1287.8
9/10/2010 9:28	37.0	Tip	15.5	1.9	13.6	333	1293.8
9/10/2010 9:30	37.1	Tip	15.5	1.9	13.6	330	1290.8
9/10/2010 9:31	36.9	Tip	15.4	1.9	13.6	330	1287.8
9/10/2010 9:33	37.0	Tip	15.4	1.9	13.6	333	1291.8
9/10/2010 9:35	37.0	Tip	15.4	1.9	13.5	333	1295.3
9/10/2010 9:36	37.0	Tip	15.4	1.9	13.5	336	1292.3
9/10/2010 9:38	37.2	Tip	15.4	1.9	13.5	336	1303.8
9/10/2010 9:40	37.1	Tip	15.4	1.9	13.5	336	1300.8
9/10/2010 9:41	37.6	Tip	15.4	1.9	13.5	336	1300.8
9/10/2010 9:43	36.8	Tip	15.4	1.9	13.5	330	1289.3
9/10/2010 9:45	36.6	Tip	15.4	1.9	13.6	330	1279.6
9/10/2010 9:46	36.7	Tip	15.4	1.9	13.6	330	1279.3
9/10/2010 9:48	36.6	Tip	15.4	1.9	13.6	327	1279.3
9/10/2010 9:50	36.4	Tip	15.4	1.9	13.6	330	1282.3
9/10/2010 9:51	36.9	Tip	15.4	1.9	13.6	330	1282.3
9/10/2010 9:53	37.3	Tip	15.4	1.9	13.6	333	1294.6
9/10/2010 9:55	36.3	Tip	15.4	1.9	13.5	327	1283.0
9/10/2010 9:56	37.2	Tip	15.4	1.9	13.5	330	1289.0
9/10/2010 9:58	36.2	Tip	15.4	1.9	13.5	327	1272.5
9/10/2010 10:00	36.3	Tip	15.4	1.9	13.5	324	1272.5
9/10/2010 10:01	36.8	Tip	15.4	1.9	13.5	327	1280.5
9/10/2010 10:03	36.8	Tip	15.4	1.9	13.5	324	1272.0
9/10/2010 10:05	36.8	Tip	15.4	1.9	13.6	327	1279.6
9/10/2010 10:06	37.4	Tip	15.4	1.9	13.6	330	1296.6
9/10/2010 10:08	37.4	Tip	15.4	1.9	13.6	333	1279.3
9/10/2010 10:10	36.9	Tip	15.5	1.9	13.6	327	1282.1
9/10/2010 10:11	37.3	Tip	15.5	1.9	13.6	333	1296.1
9/10/2010 10:13	37.3	Tip	15.5	1.9	13.6	333	1297.1
9/10/2010 10:15	37.2	Tip	15.5	1.9	13.6	333	1288.1
9/10/2010 10:16	37.2	Tip	15.5	1.9	13.6	336	1291.1
9/10/2010 10:18	37.2	Tip	15.5	1.9	13.6	333	1294.1
9/10/2010 10:20	36.9	Tip	15.5	1.9	13.6	327	1294.1

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/10/2010 10:21	37.0	Tip	15.5	1.9	13.6	330	1293.8
9/10/2010 10:23	37.0	Tip	15.5	1.9	13.6	330	1287.8
9/10/2010 10:25	37.2	Tip	15.5	1.9	13.6	330	1287.6
9/10/2010 10:26	37.6	Tip	15.5	1.9	13.6	330	1293.6
9/10/2010 10:28	37.0	Tip	15.5	1.9	13.6	330	1287.4
9/10/2010 10:30	37.3	Tip	15.5	1.9	13.6	327	1287.4
9/10/2010 10:31	36.7	Tip	15.5	1.9	13.6	330	1281.4
9/10/2010 10:33	37.3	Tip	15.5	1.9	13.6	333	1287.1
9/10/2010 10:35	37.1	Tip	15.5	1.9	13.6	333	1298.1
9/10/2010 10:36	37.0	Tip	15.5	1.9	13.6	333	1290.1
9/10/2010 10:38	37.9	Tip	15.5	1.9	13.6	333	1295.1
9/10/2010 10:40	37.5	Tip	15.5	1.9	13.6	336	1301.1
9/10/2010 10:41	37.4	Tip	15.5	1.9	13.6	333	1293.1
9/10/2010 10:43	37.3	Tip	15.5	1.9	13.6	333	1294.9
9/10/2010 10:45	37.7	Tip	15.5	1.9	13.6	336	1295.9
9/10/2010 10:46	37.4	Tip	15.5	1.9	13.6	330	1291.9
9/10/2010 10:48	36.9	Tip	15.5	1.9	13.6	327	1289.9
9/10/2010 10:50	36.1	Tip	15.5	1.9	13.6	322	1270.1
9/10/2010 10:51	37.0	Tip	15.5	1.9	13.6	330	1292.4
9/10/2010 10:53	36.4	Tip	15.5	1.9	13.6	324	1275.6
9/10/2010 10:55	36.4	Tip	15.5	1.9	13.6	322	1275.8
9/10/2010 10:56	36.5	Tip	15.5	1.9	13.6	324	1275.8
9/10/2010 10:58	36.9	Tip	15.5	1.9	13.6	324	1275.8
9/10/2010 11:00	35.7	Tip	15.5	1.9	13.6	322	1275.8
9/10/2010 11:01	36.8	Tip	15.5	1.9	13.6	327	1284.6
9/10/2010 11:03	36.8	Tip	15.5	1.9	13.6	327	1283.9
9/10/2010 11:05	36.5	Tip	15.5	1.9	13.6	324	1280.9
9/10/2010 11:06	36.2	Tip	15.5	1.9	13.6	327	1274.9
9/10/2010 11:08	36.8	Tip	15.5	1.9	13.6	324	1283.9
9/10/2010 11:10	36.4	Tip	15.5	1.9	13.6	327	1280.9
9/10/2010 11:11	36.4	Tip	15.5	1.9	13.6	324	1274.6
9/10/2010 11:13	36.5	Tip	15.5	1.9	13.6	322	1272.9
9/10/2010 11:15	36.3	Tip	15.5	1.9	13.6	324	1277.9
9/10/2010 11:16	36.6	Tip	15.5	1.9	13.6	324	1277.9
9/10/2010 11:18	36.8	Tip	15.5	1.9	13.6	327	1283.9
9/10/2010 11:20	37.1	Tip	15.5	1.9	13.6	327	1297.9
9/10/2010 11:21	37.3	Tip	15.5	1.9	13.6	330	1289.9

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/10/2010 11:23	37.2	Tip	15.5	1.9	13.6	330	1283.9
9/10/2010 11:25	37.0	Tip	15.5	1.9	13.6	327	1274.6
9/10/2010 11:26	37.0	Tip	15.5	1.9	13.7	327	1283.6
9/10/2010 11:28	37.1	Tip	15.5	1.9	13.7	330	1283.4
9/10/2010 11:30	37.0	Tip	15.5	1.9	13.7	327	1286.4
9/10/2010 11:31	37.1	Tip	15.5	1.9	13.7	324	1283.4
9/10/2010 11:33	36.0	Tip	15.5	1.9	13.7	324	1280.4
9/10/2010 11:35	36.7	Tip	15.5	1.9	13.7	327	1291.4
9/10/2010 11:36	36.9	Tip	15.5	1.9	13.7	327	1283.4
9/10/2010 11:38	36.7	Tip	15.5	1.9	13.7	327	1274.4
9/10/2010 11:40	36.9	Tip	15.5	1.9	13.6	324	1274.6
9/10/2010 11:41	37.1	Tip	15.5	1.9	13.6	327	1289.6
9/10/2010 11:43	36.3	Tip	15.5	1.9	13.6	324	1274.9
9/10/2010 11:45	36.8	Tip	15.5	1.9	13.6	324	1280.6
9/10/2010 11:46	37.0	Tip	15.5	1.9	13.7	327	1274.6
9/10/2010 11:48	37.3	Tip	15.5	1.9	13.7	330	1289.4
9/10/2010 11:50	37.1	Tip	15.6	1.9	13.7	330	1283.4
9/10/2010 11:51	36.7	Tip	15.6	1.9	13.7	327	1274.4
9/10/2010 11:53	36.9	Tip	15.6	1.9	13.7	324	1283.2
9/10/2010 11:55	36.8	Tip	15.6	1.9	13.7	324	1274.2
9/10/2010 11:56	36.9	Tip	15.6	1.9	13.7	327	1282.9
9/10/2010 11:58	36.8	Tip	15.6	1.9	13.7	324	1279.9
9/10/2010 12:00	34.4	Tip	15.6	1.9	13.7	305	1265.0
9/10/2010 12:01	36.2	Tip	15.6	1.9	13.7	319	1266.0
9/10/2010 12:03	36.2	Tip	15.6	1.9	13.6	316	1267.8
9/10/2010 12:05	35.9	Tip	15.6	1.9	13.6	316	1268.8
9/10/2010 12:06	36.1	Tip	15.6	2.0	13.6	316	1268.8
9/10/2010 12:08	35.3	Tip	15.6	2.0	13.6	313	1269.7
9/10/2010 12:10	35.8	Tip	15.6	2.0	13.6	305	1269.7
9/10/2010 12:11	35.2	Tip	15.6	2.0	13.6	305	1269.7
9/10/2010 12:13	35.4	Tip	15.6	1.9	13.7	305	1266.9
9/10/2010 12:15	35.1	Tip	15.6	1.9	13.7	305	1266.0
9/10/2010 12:16	35.4	Tip	15.6	1.9	13.7	305	1266.0
9/10/2010 12:18	35.2	Tip	15.6	1.9	13.7	305	1265.0
9/10/2010 12:20	34.8	Tip	15.6	1.9	13.7	305	1264.1
9/10/2010 12:21	34.6	Tip	15.6	1.9	13.7	305	1263.1
9/10/2010 12:23	34.9	Tip	15.6	1.9	13.7	305	1263.1

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/10/2010 12:25	35.1	Tip	15.6	1.9	13.7	305	1264.1
9/10/2010 12:26	34.3	Tip	15.6	1.9	13.7	305	1265.0
9/10/2010 12:28	34.9	Tip	15.6	1.9	13.7	305	1265.0
9/10/2010 12:30	34.9	Tip	15.6	1.9	13.7	305	1266.0
9/10/2010 12:31	35.1	Tip	15.6	1.9	13.7	305	1266.0
9/10/2010 12:33	35.7	Tip	15.6	1.9	13.7	305	1266.0
9/10/2010 12:35	35.6	Tip	15.6	1.9	13.7	305	1265.0
9/10/2010 12:36	36.0	Tip	15.6	1.9	13.7	305	1265.0
9/10/2010 12:38	35.0	Tip	15.6	1.9	13.7	305	1265.0
9/10/2010 12:40	35.1	Tip	15.6	1.9	13.7	305	1264.1
9/10/2010 12:41	34.8	Tip	15.6	1.9	13.7	305	1263.1
9/10/2010 12:43	35.1	Tip	15.6	1.9	13.7	305	1262.2
9/10/2010 12:45	35.1	Tip	15.6	1.9	13.7	305	1262.2
9/10/2010 12:46	34.9	Tip	15.6	2.0	13.7	305	1263.1
9/10/2010 12:48	34.6	Tip	15.6	2.0	13.7	305	1265.0
9/10/2010 12:50	35.1	Tip	15.6	2.0	13.7	305	1265.0
9/10/2010 12:51	34.9	Tip	15.6	2.0	13.7	305	1265.0
9/10/2010 12:53	34.7	Tip	15.6	2.0	13.7	305	1265.0
9/10/2010 12:55	34.9	Tip	15.6	2.0	13.7	305	1265.0
9/10/2010 12:56	34.9	Tip	15.6	2.0	13.7	305	1265.0
9/10/2010 12:58	34.9	Tip	15.6	2.0	13.7	305	1265.0
9/10/2010 13:00	35.7	Tip	15.6	1.9	13.7	313	1264.1
9/10/2010 13:01	36.2	Tip	15.6	1.9	13.7	316	1264.1
9/10/2010 13:03	35.9	Tip	15.6	1.9	13.7	316	1264.1
9/10/2010 13:05	35.6	Tip	15.6	1.9	13.7	316	1264.1
9/10/2010 13:06	35.9	Tip	15.6	1.9	13.7	313	1264.1
9/10/2010 13:08	35.7	Tip	15.6	1.9	13.7	313	1264.1
9/10/2010 13:10	35.1	Tip	15.6	1.9	13.7	305	1264.1
9/10/2010 13:11	35.5	Tip	15.6	1.9	13.7	305	1264.1
9/10/2010 13:13	35.1	Tip	15.6	1.9	13.7	305	1263.1
9/10/2010 13:15	34.9	Tip	15.6	1.9	13.7	305	1262.2
9/10/2010 13:16	35.1	Tip	15.6	1.9	13.7	305	1262.2
9/10/2010 13:18	35.0	Tip	15.6	1.9	13.7	305	1262.2
9/10/2010 13:20	35.3	Tip	15.6	1.9	13.7	305	1261.3
9/10/2010 13:21	35.0	Tip	15.6	1.9	13.7	305	1261.3
9/10/2010 13:23	34.9	Tip	15.6	1.9	13.7	305	1261.3
9/10/2010 13:25	35.5	Tip	15.6	1.9	13.7	305	1260.3

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/10/2010 13:26	34.7	Tip	15.7	1.9	13.7	305	1259.4
9/10/2010 13:28	34.9	Tip	15.7	1.9	13.7	305	1258.4
9/10/2010 13:30	35.2	Tip	15.7	1.9	13.7	302	1219.5
9/10/2010 13:31	35.3	Tip	15.7	1.9	13.7	308	1234.5
9/10/2010 13:33	35.6	Tip	15.7	1.9	13.7	310	1234.5
9/10/2010 13:35	37.6	Tip	15.7	1.9	13.7	330	1253.5
9/10/2010 13:36	36.6	Tip	15.7	1.9	13.7	324	1253.2
9/10/2010 13:38	36.5	Tip	15.7	1.9	13.7	322	1248.2
9/10/2010 13:40	36.8	Tip	15.7	1.9	13.7	322	1245.2
9/10/2010 13:41	36.7	Tip	15.7	1.9	13.7	322	1245.2
9/10/2010 13:43	37.2	Tip	15.7	1.9	13.7	324	1242.2
9/10/2010 13:45	36.9	Tip	15.7	1.9	13.7	322	1256.2
9/10/2010 13:46	36.9	Tip	15.7	1.9	13.7	324	1248.2
9/10/2010 13:48	37.2	Tip	15.7	1.9	13.7	322	1250.2
9/10/2010 13:50	36.5	Tip	15.7	1.9	13.7	322	1245.2
9/10/2010 13:51	36.8	Tip	15.7	1.9	13.7	322	1245.2
9/10/2010 13:53	36.5	Tip	15.7	1.9	13.7	322	1245.2
9/10/2010 13:55	36.6	Tip	15.7	1.9	13.8	319	1236.0
9/10/2010 13:56	36.3	Tip	15.7	1.9	13.8	322	1236.0
9/10/2010 13:58	36.8	Tip	15.7	1.9	13.8	319	1236.0
9/10/2010 14:00	36.8	Tip	15.7	1.9	13.8	324	1249.8
9/10/2010 14:01	37.4	Tip	15.7	1.9	13.8	330	1266.8
9/10/2010 14:03	37.2	Tip	15.7	1.9	13.8	324	1255.8
9/10/2010 14:05	37.1	Tip	15.7	1.9	13.7	324	1250.2
9/10/2010 14:06	37.0	Tip	15.7	1.9	13.7	324	1250.0
9/10/2010 14:08	36.6	Tip	15.7	1.9	13.7	327	1256.2
9/10/2010 14:10	37.0	Tip	15.7	2.0	13.7	322	1250.5
9/10/2010 14:11	37.1	Tip	15.7	2.0	13.7	327	1259.2
9/10/2010 14:13	37.0	Tip	15.7	2.0	13.7	322	1248.2
9/10/2010 14:15	36.7	Tip	15.7	2.0	13.7	322	1242.5
9/10/2010 14:16	36.5	Tip	15.7	2.0	13.7	322	1239.5
9/10/2010 14:18	36.9	Tip	15.7	2.0	13.7	319	1245.5
9/10/2010 14:20	36.6	Tip	15.7	1.9	13.7	319	1236.2
9/10/2010 14:21	37.1	Tip	15.7	1.9	13.8	324	1259.0
9/10/2010 14:23	36.6	Tip	15.7	1.9	13.8	322	1244.5
9/10/2010 14:25	36.5	Tip	15.7	1.9	13.8	319	1238.8
9/10/2010 14:26	36.8	Tip	15.7	1.9	13.8	319	1235.8

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/10/2010 14:28	36.8	Tip	15.7	1.9	13.8	319	1235.8
9/10/2010 14:30	36.6	Tip	15.7	1.9	13.8	319	1241.8
9/10/2010 14:31	37.5	Tip	15.7	1.9	13.8	330	1266.8
9/10/2010 14:33	37.6	Tip	15.7	1.9	13.8	324	1263.5
9/10/2010 14:35	37.3	Tip	15.7	1.9	13.8	327	1249.3
9/10/2010 14:36	37.0	Tip	15.7	1.9	13.8	322	1244.3
9/10/2010 14:38	37.2	Tip	15.7	1.9	13.8	324	1255.3
9/10/2010 14:40	36.9	Tip	15.7	1.9	13.8	324	1249.3
9/10/2010 14:41	37.2	Tip	15.7	1.9	13.8	322	1249.3
9/10/2010 14:43	37.0	Tip	15.7	1.9	13.8	322	1244.3
9/10/2010 14:45	36.6	Tip	15.7	1.9	13.8	319	1238.0
9/10/2010 14:46	37.2	Tip	15.7	1.9	13.8	327	1257.8
9/10/2010 14:48	36.4	Tip	15.7	1.9	13.8	319	1234.8
9/10/2010 14:50	37.3	Tip	15.7	1.9	13.8	324	1257.8
9/10/2010 14:51	36.7	Tip	15.7	1.9	13.8	322	1240.8
9/10/2010 14:53	36.7	Tip	15.7	1.9	13.8	322	1234.8
9/10/2010 14:55	36.8	Tip	15.7	1.9	13.8	319	1241.3
9/10/2010 14:56	36.2	Tip	15.7	1.9	13.8	319	1229.3
9/10/2010 14:58	36.9	Tip	15.7	1.9	13.8	319	1241.0
9/10/2010 15:00	37.4	Tip	15.7	1.9	13.8	324	1249.5
9/10/2010 15:01	37.1	Tip	15.7	1.9	13.8	322	1244.5
9/10/2010 15:03	36.7	Tip	15.7	1.9	13.8	319	1241.5
9/10/2010 15:05	36.5	Tip	15.7	1.9	13.8	319	1238.5
9/10/2010 15:06	36.6	Tip	15.7	1.9	13.8	324	1247.3
9/10/2010 15:08	36.9	Tip	15.7	1.9	13.8	324	1249.3
9/10/2010 15:10	37.0	Tip	15.7	1.9	13.8	322	1241.5
9/10/2010 15:11	37.2	Tip	15.7	1.9	13.8	322	1241.5
9/10/2010 15:13	36.6	Tip	15.7	1.9	13.8	319	1238.5
9/10/2010 15:15	36.1	Tip	15.7	1.9	13.8	316	1226.8
9/10/2010 15:16	36.8	Tip	15.7	1.9	13.8	319	1235.8
9/10/2010 15:18	36.2	Tip	15.7	1.9	13.8	319	1229.8
9/10/2010 15:20	36.7	Tip	15.7	1.9	13.8	322	1241.8
9/10/2010 15:21	37.1	Tip	15.7	1.9	13.8	327	1252.5
9/10/2010 15:23	37.5	Tip	15.7	1.9	13.8	324	1258.5
9/10/2010 15:25	36.6	Tip	15.7	1.9	13.8	327	1258.3
9/10/2010 15:26	37.5	Tip	15.7	1.9	13.8	324	1252.3
9/10/2010 15:28	37.0	Tip	15.7	1.9	13.8	319	1238.3

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/10/2010 15:30	36.7	Tip	15.7	1.9	13.8	322	1241.0
9/10/2010 15:31	36.8	Tip	15.7	1.9	13.8	319	1235.0
9/10/2010 15:33	37.0	Tip	15.7	1.9	13.8	322	1241.0
9/10/2010 15:35	37.3	Tip	15.7	1.9	13.8	322	1252.3
9/10/2010 15:36	37.3	Tip	15.7	1.9	13.8	327	1261.0
9/10/2010 15:38	37.3	Tip	15.7	1.9	13.8	327	1247.3
9/10/2010 15:40	36.8	Tip	15.7	1.9	13.8	319	1238.3
9/10/2010 15:41	37.0	Tip	15.7	1.9	13.8	324	1252.3
9/10/2010 15:43	37.1	Tip	15.7	1.9	13.8	322	1244.0
9/10/2010 15:45	36.8	Tip	15.7	1.9	13.8	322	1249.0
9/10/2010 15:46	37.0	Tip	15.7	1.9	13.8	324	1244.0
9/10/2010 15:48	36.9	Tip	15.7	1.9	13.8	324	1246.0
9/10/2010 15:50	36.7	Tip	15.7	1.9	13.8	319	1235.0
9/10/2010 15:51	37.0	Tip	15.7	1.9	13.8	322	1247.0
9/10/2010 15:53	37.3	Tip	15.7	1.9	13.8	324	1251.8
9/10/2010 15:55	37.7	Tip	15.7	1.9	13.8	324	1254.8
9/10/2010 15:56	37.2	Tip	15.7	1.9	13.8	324	1251.6
9/10/2010 15:58	37.2	Tip	15.7	1.9	13.8	324	1248.6
9/10/2010 16:00	37.0	Tip	15.7	1.9	13.8	322	1240.6
9/10/2010 16:01	37.5	Tip	15.7	1.9	13.8	324	1251.6
9/10/2010 16:03	37.2	Tip	15.7	1.9	13.8	327	1257.6
9/10/2010 16:05	37.5	Tip	15.7	1.9	13.8	330	1265.6
9/10/2010 16:06	37.9	Tip	15.7	1.9	13.8	333	1273.6
9/10/2010 16:08	37.8	Tip	15.7	1.9	13.8	330	1270.6
9/10/2010 16:10	37.2	Tip	15.7	1.9	13.8	324	1179.6
9/10/2010 16:11	37.4	Tip	15.7	1.9	13.8	327	1192.3
9/10/2010 16:13	37.5	Tip	15.7	1.9	13.8	330	1198.1
9/10/2010 16:15	37.5	Tip	15.8	1.9	13.9	324	1199.6
9/10/2010 16:16	37.8	Tip	15.8	1.9	13.9	324	1193.6
9/10/2010 16:18	37.6	Tip	15.8	1.9	13.9	327	1199.1
9/10/2010 16:20	37.3	Tip	15.8	1.9	13.9	324	1190.9
9/10/2010 16:21	37.0	Tip	15.8	1.9	13.9	319	1177.9
9/10/2010 16:23	37.1	Tip	15.8	1.9	13.9	319	1177.9
9/10/2010 16:25	36.9	Tip	15.8	1.9	13.9	319	1177.9
9/10/2010 16:26	36.9	Tip	15.7	1.9	13.9	316	1172.1
9/10/2010 16:28	36.9	Tip	15.7	1.9	13.9	319	1178.1
9/10/2010 16:30	36.6	Tip	15.7	1.9	13.9	319	1177.9

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/10/2010 16:31	37.4	Tip	15.7	1.9	13.9	324	1185.9
9/10/2010 16:33	37.2	Tip	15.7	1.9	13.9	324	1192.9
9/10/2010 16:35	37.3	Tip	15.8	1.9	13.9	327	1198.6
9/10/2010 16:36	37.4	Tip	15.7	1.9	13.9	327	1201.6
9/10/2010 16:38	38.0	Tip	15.7	1.9	13.9	330	1201.9
9/10/2010 16:40	37.2	Tip	15.7	1.9	13.9	322	1188.9
9/10/2010 16:41	37.2	Tip	15.7	1.9	13.9	327	1204.6
9/10/2010 16:43	37.6	Tip	15.7	1.9	13.9	324	1196.1
9/10/2010 16:45	37.8	Tip	15.7	1.9	13.9	327	1207.9
9/10/2010 16:46	38.0	Tip	15.7	1.9	13.9	327	1198.9
9/10/2010 16:48	37.6	Tip	15.7	1.9	13.9	324	1195.6
9/10/2010 16:50	37.7	Tip	15.8	1.9	13.9	324	1204.4
9/10/2010 16:51	37.7	Tip	15.8	1.8	13.9	324	1188.4
9/10/2010 16:53	37.1	Tip	15.8	1.8	13.9	319	1181.9
9/10/2010 16:55	36.9	Tip	15.8	1.8	13.9	319	1182.2
9/10/2010 16:56	37.1	Tip	15.8	1.8	13.9	322	1185.2
9/10/2010 16:58	36.7	Tip	15.7	1.8	13.9	319	1179.2
9/10/2010 17:00	36.7	Tip	15.7	1.9	13.9	316	1174.9
9/10/2010 17:01	37.3	Tip	15.7	1.9	13.9	324	1192.9
9/10/2010 17:03	37.4	Tip	15.7	1.9	13.9	319	1191.4
9/10/2010 17:05	37.0	Tip	15.7	1.9	13.9	322	1189.4
9/10/2010 17:06	37.3	Tip	15.7	1.9	13.9	322	1191.4
9/10/2010 17:08	37.6	Tip	15.7	1.9	13.9	324	1196.4
9/10/2010 17:10	36.5	Tip	15.7	1.9	13.9	324	1193.4
9/10/2010 17:11	37.6	Tip	15.7	1.9	13.9	327	1202.1
9/10/2010 17:13	36.9	Tip	15.7	1.9	13.9	319	1183.1
9/10/2010 17:15	37.7	Tip	15.7	1.8	13.9	327	1202.1
9/10/2010 17:16	38.0	Tip	15.7	1.8	13.9	330	1214.1
9/10/2010 17:18	37.8	Tip	15.7	1.8	13.9	330	1211.1
9/10/2010 17:20	37.6	Tip	15.7	1.8	13.9	324	1202.1
9/10/2010 17:21	37.7	Tip	15.7	1.8	13.9	324	1195.9
9/10/2010 17:23	37.5	Tip	15.7	1.8	13.9	324	1190.9
9/10/2010 17:25	37.0	Tip	15.7	1.8	13.9	319	1189.1
9/10/2010 17:26	36.4	Tip	15.7	1.8	13.9	316	1175.1
9/10/2010 17:28	36.7	Tip	15.7	1.8	13.9	316	1172.1
9/10/2010 17:30	36.8	Tip	15.7	1.8	13.9	316	1183.1
9/10/2010 17:31	36.9	Tip	15.7	1.8	13.9	319	1183.1

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/10/2010 18:06	37.1	control	15.7	1.8	13.9	322	1192.2
9/10/2010 18:08	37.6	control	15.7	1.8	13.9	324	1195.2
9/10/2010 18:10	37.4	control	15.7	1.8	13.9	322	1188.4
9/10/2010 18:11	37.1	control	15.7	1.8	13.9	322	1182.4
9/10/2010 18:13	37.8	control	15.7	1.8	13.9	322	1198.2
9/10/2010 18:15	37.8	control	15.7	1.8	13.9	327	1198.2
9/10/2010 18:16	37.6	control	15.7	1.8	13.9	324	1192.2
9/10/2010 18:18	37.5	control	15.7	1.8	13.9	324	1194.9
9/10/2010 18:20	37.6	control	15.7	1.8	13.9	327	1200.9
9/10/2010 18:21	38.0	control	15.7	1.8	13.9	324	1194.9
9/10/2010 18:23	37.4	control	15.7	1.8	13.9	324	1187.7
9/10/2010 18:25	37.8	control	15.7	1.8	13.9	324	1200.9
9/10/2010 18:26	37.6	control	15.7	1.8	13.9	327	1197.9
9/10/2010 18:28	37.5	control	15.7	1.8	13.9	324	1187.9
9/10/2010 18:30	37.3	control	15.7	1.8	13.9	322	1187.9
9/10/2010 18:31	37.6	control	15.7	1.8	13.9	324	1194.9
9/10/2010 18:33	37.1	control	15.7	1.8	13.9	322	1182.2
9/10/2010 18:35	37.7	control	15.7	1.8	13.9	324	1201.2
9/10/2010 18:36	37.1	control	15.7	1.8	13.9	319	1176.2
9/10/2010 18:38	37.0	control	15.7	1.8	13.9	322	1188.2
9/10/2010 18:40	37.7	control	15.7	1.8	13.9	322	1192.2
9/10/2010 18:41	37.3	control	15.7	1.8	13.9	322	1188.2
9/10/2010 18:43	37.5	control	15.7	1.8	13.9	322	1195.2
9/10/2010 18:45	37.8	control	15.7	1.8	13.9	327	1207.4
9/10/2010 18:46	38.0	control	15.7	1.8	13.9	330	1201.4
9/10/2010 18:48	38.1	control	15.7	1.8	13.9	327	1213.6
9/10/2010 18:50	37.7	control	15.7	1.8	13.9	327	1198.9
9/10/2010 18:51	37.6	control	15.7	1.8	13.9	324	1192.9
9/10/2010 18:53	37.9	control	15.7	1.8	13.9	327	1211.1
9/11/2010 8:36	37.3	control	15.7	1.2	14.4	305	1125.8
9/11/2010 8:38	37.4	control	15.7	1.2	14.4	302	1140.2
9/11/2010 8:40	37.1	control	15.7	1.3	14.4	305	1143.8
9/11/2010 8:41	37.3	control	15.7	1.3	14.4	305	1147.0
9/11/2010 8:43	36.8	control	15.7	1.3	14.4	302	1138.0
9/11/2010 8:45	37.5	control	15.7	1.3	14.4	310	1160.2

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/11/2010 8:46	37.2	control	15.7	1.3	14.4	308	1164.2
9/11/2010 8:48	37.0	control	15.7	1.3	14.4	308	1175.4
9/11/2010 8:50	37.1	control	15.7	1.3	14.4	305	1172.7
9/11/2010 8:51	37.0	control	15.7	1.3	14.3	305	1172.9
9/11/2010 8:53	36.7	control	15.7	1.3	14.3	305	1167.9
9/11/2010 8:55	37.2	control	15.7	1.3	14.3	308	1176.1
9/11/2010 8:56	36.8	control	15.7	1.4	14.3	302	1165.1
9/11/2010 8:58	36.1	control	15.7	1.4	14.3	294	1141.5
9/11/2010 9:00	35.6	control	15.7	1.4	14.3	291	1134.7
9/11/2010 9:01	34.7	control	15.6	1.4	14.3	291	1198.9
9/11/2010 9:03	37.5	control	15.6	1.4	14.3	313	1236.3
9/11/2010 9:05	37.4	control	15.6	1.4	14.2	316	1247.0
9/11/2010 9:06	37.4	control	15.6	1.4	14.2	316	1242.6
9/11/2010 9:08	37.6	control	15.6	1.5	14.2	319	1232.6
9/11/2010 9:10	37.5	control	15.6	1.5	14.1	316	1224.5
9/11/2010 9:11	37.9	control	15.6	1.5	14.1	322	1236.7
9/11/2010 9:13	37.8	control	15.6	1.5	14.1	322	1231.1
9/11/2010 9:15	37.4	control	15.6	1.5	14.1	319	1237.5
9/11/2010 9:16	38.2	control	15.6	1.6	14.1	324	1245.5
9/11/2010 9:18	37.7	control	15.6	1.6	14.1	324	1246.0
9/11/2010 9:20	38.2	control	15.6	1.6	14.1	327	1257.0
9/11/2010 9:21	38.4	control	15.6	1.6	14.0	327	1254.2
9/11/2010 9:23	37.9	control	15.6	1.6	14.0	327	1257.2
9/11/2010 9:25	38.1	control	15.6	1.6	14.0	324	1262.4
9/11/2010 9:26	37.4	control	15.6	1.6	14.0	322	1260.4
9/11/2010 9:28	36.9	control	15.6	1.6	14.0	313	1235.2
9/11/2010 9:30	37.0	control	15.6	1.6	14.0	316	1235.2
9/11/2010 9:51	35.8	mid	15.6	1.6	13.9	310	1225.4
9/11/2010 9:53	36.4	mid	15.6	1.6	13.9	316	1240.4
9/11/2010 9:55	36.8	mid	15.6	1.6	13.9	316	1245.4
9/11/2010 9:56	36.6	mid	15.6	1.6	13.9	316	1242.4
9/11/2010 9:58	35.8	mid	15.6	1.6	13.9	305	1218.7
9/11/2010 10:00	35.7	mid	15.6	1.6	13.9	308	1220.9
9/11/2010 10:01	35.9	mid	15.6	1.7	13.9	310	1219.2
9/11/2010 10:03	35.6	mid	15.6	1.7	13.9	305	1213.2
9/11/2010 10:05	35.6	mid	15.6	1.7	13.9	305	1213.6

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/11/2010 10:06	35.7	mid	15.6	1.7	13.9	310	1223.6
9/11/2010 10:08	36.0	mid	15.6	1.7	13.9	310	1226.6
9/11/2010 10:10	35.9	mid	15.6	1.7	13.9	310	1229.6
9/11/2010 10:11	35.9	mid	15.6	1.7	13.9	310	1224.9
9/11/2010 10:13	36.2	mid	15.5	1.7	13.9	310	1227.1
9/11/2010 10:15	36.1	mid	15.5	1.7	13.9	310	1230.4
9/11/2010 10:16	35.7	mid	15.6	1.7	13.9	308	1217.1
9/11/2010 10:18	36.2	mid	15.6	1.7	13.9	310	1227.1
9/11/2010 10:20	36.5	mid	15.6	1.7	13.9	313	1233.1
9/11/2010 10:21	36.3	mid	15.6	1.7	13.9	310	1226.9
9/11/2010 10:23	36.9	mid	15.6	1.7	13.9	316	1249.9
9/11/2010 10:25	36.1	mid	15.6	1.7	13.9	313	1238.9
9/11/2010 10:26	36.4	mid	15.6	1.7	13.9	319	1238.9
9/11/2010 10:28	35.9	mid	15.6	1.7	13.9	310	1227.1
9/11/2010 10:30	36.1	mid	15.6	1.7	13.9	308	1239.6
9/11/2010 10:31	35.7	mid	15.6	1.7	13.8	313	1234.1
9/11/2010 10:33	35.7	mid	15.5	1.7	13.8	310	1231.6
9/11/2010 10:35	36.0	mid	15.5	1.7	13.8	313	1234.8
9/11/2010 10:36	36.0	mid	15.5	1.8	13.8	313	1226.0
9/11/2010 10:38	35.6	mid	15.5	1.8	13.8	308	1222.0
9/11/2010 10:40	35.4	mid	15.6	1.8	13.8	305	1215.8
9/11/2010 10:41	35.2	mid	15.6	1.8	13.8	308	1221.8
9/11/2010 10:43	35.5	mid	15.6	1.8	13.8	308	1224.0
9/11/2010 10:45	35.7	mid	15.6	1.8	13.8	310	1226.0
9/11/2010 10:46	35.9	mid	15.6	1.8	13.8	308	1221.8
9/11/2010 10:48	35.6	mid	15.6	1.7	13.8	308	1221.6
9/11/2010 10:50	35.8	mid	15.5	1.7	13.8	310	1225.8
9/11/2010 10:51	35.8	mid	15.5	1.8	13.8	308	1222.0
9/11/2010 10:53	35.5	mid	15.6	1.8	13.8	308	1223.8
9/11/2010 10:55	36.1	mid	15.6	1.8	13.8	316	1245.8
9/11/2010 10:56	36.1	mid	15.6	1.8	13.8	310	1228.8
9/11/2010 10:58	35.2	mid	15.6	1.8	13.8	305	1212.8
9/11/2010 11:00	35.3	mid	15.6	1.8	13.8	308	1219.0
9/11/2010 11:01	35.1	mid	15.6	1.8	13.8	308	1213.0
9/11/2010 11:03	34.9	mid	15.6	1.8	13.8	305	1213.0
9/11/2010 11:05	35.8	mid	15.5	1.8	13.8	310	1229.5
9/11/2010 11:06	35.6	mid	15.5	1.8	13.8	313	1235.5

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/11/2010 11:08	35.7	mid	15.5	1.8	13.8	313	1229.5
9/11/2010 11:10	36.2	mid	15.5	1.8	13.8	313	1238.5
9/11/2010 11:11	36.0	mid	15.5	1.8	13.8	313	1238.5
9/11/2010 11:13	35.7	mid	15.5	1.8	13.8	310	1229.8
9/11/2010 11:15	36.3	mid	15.5	1.8	13.8	316	1246.8
9/11/2010 11:16	35.8	mid	15.6	1.8	13.8	310	1232.8
9/11/2010 11:18	36.2	mid	15.6	1.8	13.8	316	1238.5
9/11/2010 11:20	36.3	mid	15.6	1.8	13.8	313	1243.5
9/11/2010 11:21	35.7	mid	15.6	1.8	13.8	316	1246.5
9/11/2010 11:23	36.0	mid	15.6	1.8	13.8	310	1232.5
9/11/2010 11:25	35.8	mid	15.6	1.8	13.8	313	1235.5
9/11/2010 11:26	35.8	mid	15.6	1.8	13.8	310	1229.8
9/11/2010 11:28	35.6	mid	15.6	1.8	13.8	313	1229.8
9/11/2010 11:30	35.7	mid	15.6	1.8	13.8	310	1230.0
9/11/2010 11:31	35.7	mid	15.6	1.8	13.8	313	1239.0
9/11/2010 11:33	35.4	mid	15.6	1.8	13.8	310	1230.0
9/11/2010 11:35	35.4	mid	15.6	1.8	13.8	310	1228.0
9/11/2010 11:36	35.0	mid	15.6	1.8	13.8	308	1214.0
9/11/2010 11:38	35.6	mid	15.6	1.8	13.8	310	1230.0
9/11/2010 11:40	35.9	mid	15.6	1.8	13.8	316	1230.0
9/11/2010 11:41	36.2	mid	15.6	1.8	13.7	316	1247.0
9/11/2010 11:43	36.0	mid	15.6	1.8	13.8	310	1242.0
9/11/2010 11:45	36.0	mid	15.6	1.8	13.8	313	1235.8
9/11/2010 11:46	35.6	mid	15.6	1.8	13.8	310	1229.8
9/11/2010 11:48	36.1	mid	15.6	1.8	13.8	313	1238.5
9/11/2010 11:50	35.9	mid	15.6	1.8	13.8	316	1238.3
9/11/2010 11:51	36.0	mid	15.6	1.8	13.8	313	1241.3
9/11/2010 11:53	35.9	mid	15.6	1.8	13.8	313	1232.5
9/11/2010 11:55	35.8	mid	15.6	1.8	13.8	313	1238.5
9/11/2010 11:56	35.7	mid	15.6	1.8	13.8	313	1238.5
9/11/2010 11:58	35.3	mid	15.6	1.8	13.8	308	1227.8
9/11/2010 12:00	35.7	mid	15.6	1.8	13.8	308	1224.8
9/11/2010 12:01	36.1	mid	15.6	1.8	13.8	316	1246.8
9/11/2010 12:03	36.3	mid	15.6	1.8	13.8	313	1247.0
9/11/2010 12:05	35.8	mid	15.6	1.8	13.8	313	1239.0
9/11/2010 12:06	35.8	mid	15.6	1.8	13.8	313	1242.0
9/11/2010 12:08	35.8	mid	15.6	1.8	13.8	313	1239.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/11/2010 12:10	35.8	mid	15.6	1.8	13.7	316	1245.2
9/11/2010 12:11	35.7	mid	15.6	1.9	13.7	316	1239.2
9/11/2010 12:13	35.7	mid	15.6	1.9	13.7	313	1245.7
9/11/2010 12:15	35.4	mid	15.6	1.9	13.7	313	1246.0
9/11/2010 12:16	35.9	mid	15.6	1.9	13.7	313	1240.0
9/11/2010 12:18	35.9	mid	15.6	1.9	13.7	313	1245.4
9/11/2010 12:20	35.6	mid	15.6	1.9	13.7	310	1231.7
9/11/2010 12:21	35.4	mid	15.6	1.9	13.7	308	1224.7
9/11/2010 12:23	34.7	mid	15.6	1.9	13.7	305	1263.1
9/11/2010 12:25	35.2	mid	15.6	1.9	13.7	305	1263.1
9/11/2010 12:26	35.4	mid	15.6	1.9	13.7	313	1263.1
9/11/2010 12:28	35.0	mid	15.6	1.9	13.7	305	1260.3
9/11/2010 12:30	35.4	mid	15.6	1.9	13.7	305	1259.4
9/11/2010 12:31	35.9	mid	15.6	1.9	13.7	313	1260.3
9/11/2010 12:33	35.7	mid	15.6	1.9	13.7	313	1261.3
9/11/2010 12:35	35.5	mid	15.6	1.9	13.7	305	1262.2
9/11/2010 12:36	35.4	mid	15.6	1.9	13.7	305	1262.2
9/11/2010 12:38	35.4	mid	15.6	1.9	13.7	305	1262.2
9/11/2010 12:40	35.7	mid	15.6	1.9	13.7	305	1261.3
9/11/2010 12:41	35.6	mid	15.6	1.9	13.7	305	1260.3
9/11/2010 12:43	35.5	mid	15.6	1.9	13.7	305	1259.4
9/11/2010 12:45	35.6	mid	15.6	1.9	13.7	305	1258.4
9/11/2010 12:46	35.2	mid	15.6	1.9	13.8	305	1257.5
9/11/2010 12:48	34.8	mid	15.6	1.9	13.8	305	1256.6
9/11/2010 12:50	34.6	mid	15.6	1.9	13.8	305	1256.6
9/11/2010 12:51	35.1	mid	15.6	1.9	13.8	305	1256.6
9/11/2010 12:53	35.0	mid	15.6	1.9	13.8	305	1257.5
9/11/2010 12:55	34.6	mid	15.6	1.9	13.7	305	1259.4
9/11/2010 12:56	35.1	mid	15.6	1.9	13.7	305	1259.4
9/11/2010 12:58	35.2	mid	15.6	1.9	13.7	305	1261.3
9/11/2010 13:00	34.8	mid	15.6	1.9	13.7	305	1262.2
9/11/2010 13:01	35.0	mid	15.6	1.9	13.7	308	1262.2
9/11/2010 13:03	34.4	mid	15.6	1.9	13.7	299	1261.3
9/11/2010 13:05	33.5	mid	15.6	1.9	13.7	294	1260.3
9/11/2010 13:06	33.7	mid	15.6	1.9	13.8	288	1259.4
9/11/2010 13:08	33.6	mid	15.6	1.9	13.8	288	1256.6
9/11/2010 13:10	33.2	mid	15.7	1.9	13.8	277	1253.7

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/11/2010 13:11	32.4	mid	15.7	1.9	13.8	277	1252.8
9/11/2010 13:13	32.9	mid	15.7	1.9	13.8	277	1251.9
9/11/2010 13:15	32.8	mid	15.7	1.9	13.8	277	1250.9
9/11/2010 13:16	32.8	mid	15.7	1.9	13.8	277	1250.9
9/11/2010 13:18	32.9	mid	15.7	1.9	13.8	277	1252.8
9/11/2010 13:20	33.0	mid	15.7	1.9	13.8	277	1252.8
9/11/2010 13:21	33.1	mid	15.6	1.9	13.8	285	1253.7
9/11/2010 13:23	33.3	mid	15.6	1.9	13.8	277	1253.7
9/11/2010 13:25	32.9	mid	15.7	1.9	13.8	277	1253.7
9/11/2010 13:26	34.8	mid	15.7	1.9	13.8	305	1229.7
9/11/2010 13:28	35.1	mid	15.7	1.9	13.8	302	1156.3
9/11/2010 13:30	35.1	mid	15.7	1.9	13.8	302	1156.3
9/11/2010 13:31	35.2	mid	15.7	1.9	13.8	310	1171.5
9/11/2010 13:33	35.3	mid	15.7	1.9	13.8	308	1168.5
9/11/2010 13:35	35.9	mid	15.7	1.9	13.8	310	1179.5
9/11/2010 13:36	35.1	mid	15.7	1.9	13.8	305	1165.5
9/11/2010 13:38	34.6	mid	15.7	1.9	13.8	299	1156.3
9/11/2010 13:40	34.7	mid	15.7	1.9	13.8	299	1151.3
9/11/2010 13:41	34.9	mid	15.7	1.9	13.8	305	1162.0
9/11/2010 13:43	35.6	mid	15.7	1.9	13.8	305	1158.8
9/11/2010 13:45	35.6	mid	15.7	1.9	13.8	305	1161.6
9/11/2010 13:46	35.5	mid	15.7	1.9	13.8	308	1167.6
9/11/2010 13:48	35.3	mid	15.7	1.9	13.8	302	1161.3
9/11/2010 13:50	35.6	mid	15.7	1.9	13.8	305	1164.3
9/11/2010 13:51	35.3	mid	15.7	1.9	13.8	305	1164.3
9/11/2010 13:53	35.0	mid	15.7	1.9	13.8	302	1155.1
9/11/2010 13:55	35.7	mid	15.7	1.9	13.8	308	1167.1
9/11/2010 13:56	35.8	mid	15.7	1.9	13.8	308	1167.3
9/11/2010 13:58	35.3	mid	15.7	1.9	13.8	308	1173.6
9/11/2010 14:00	36.0	mid	15.7	1.9	13.8	310	1175.6
9/11/2010 14:01	36.7	mid	15.7	1.9	13.8	316	1198.6
9/11/2010 14:03	36.8	mid	15.7	1.9	13.8	319	1200.3
9/11/2010 14:05	36.6	mid	15.7	1.8	13.9	316	1199.6
9/11/2010 14:06	36.1	mid	15.7	1.8	13.9	310	1174.4
9/11/2010 14:08	36.3	mid	15.7	1.8	13.9	313	1182.9
9/11/2010 14:10	36.1	mid	15.7	1.8	13.9	308	1171.4
9/11/2010 14:11	35.8	mid	15.7	1.8	13.9	310	1171.4

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/11/2010 14:13	35.7	mid	15.7	1.8	13.9	308	1162.6
9/11/2010 14:15	35.5	mid	15.7	1.8	13.9	308	1173.9
9/11/2010 14:16	36.1	mid	15.7	1.8	13.9	310	1173.6
9/11/2010 14:18	35.6	mid	15.7	1.8	13.9	305	1162.6
9/11/2010 14:20	35.3	mid	15.7	1.8	13.9	302	1159.6
9/11/2010 14:21	35.3	mid	15.7	1.8	13.9	302	1149.4
9/11/2010 14:23	35.5	mid	15.7	1.8	13.9	299	1148.2
9/11/2010 14:25	35.4	mid	15.7	1.8	13.9	302	1150.9
9/11/2010 14:26	35.6	mid	15.7	1.8	13.9	302	1148.9
9/11/2010 14:28	35.1	mid	15.7	1.8	13.9	299	1145.9
9/11/2010 14:30	35.7	mid	15.7	1.8	13.9	302	1155.4
9/11/2010 14:31	35.9	mid	15.7	1.8	13.9	305	1161.4
9/11/2010 14:33	35.8	mid	15.7	1.8	13.9	305	1155.4
9/11/2010 14:35	35.5	mid	15.7	1.8	13.9	305	1158.4
9/11/2010 14:36	35.7	mid	15.7	1.8	13.9	308	1158.4
9/11/2010 14:38	35.7	mid	15.7	1.8	13.9	305	1161.9
9/11/2010 14:40	35.9	mid	15.7	1.8	13.9	308	1168.2
9/11/2010 14:41	36.0	mid	15.7	1.8	13.9	308	1165.2
9/11/2010 14:43	35.6	mid	15.7	1.8	13.9	302	1159.2
9/11/2010 14:45	35.6	mid	15.7	1.8	13.9	305	1153.2
9/11/2010 14:46	36.1	mid	15.7	1.8	13.9	308	1171.2
9/11/2010 14:48	35.9	mid	15.7	1.8	13.9	308	1159.2
9/11/2010 14:50	35.7	mid	15.7	1.8	13.9	302	1152.9
9/11/2010 14:51	35.2	mid	15.7	1.8	13.9	302	1148.7
9/11/2010 14:53	35.9	mid	15.7	1.8	13.9	305	1158.7
9/11/2010 14:55	35.5	mid	15.7	1.8	13.9	302	1158.4
9/11/2010 14:56	35.2	mid	15.7	1.8	13.9	305	1158.4
9/11/2010 14:58	35.7	mid	15.7	1.8	13.9	305	1158.4
9/11/2010 15:00	35.5	mid	15.7	1.8	14.0	302	1152.2
9/11/2010 15:01	36.1	mid	15.7	1.8	14.0	308	1164.2
9/11/2010 15:03	36.1	mid	15.7	1.8	14.0	313	1178.0
9/11/2010 15:05	36.3	mid	15.7	1.8	14.0	310	1172.0
9/11/2010 15:06	36.2	mid	15.7	1.8	14.0	310	1172.0
9/11/2010 15:08	36.1	mid	15.7	1.8	14.0	308	1167.0
9/11/2010 15:10	36.1	mid	15.7	1.8	14.0	308	1172.0
9/11/2010 15:11	36.4	mid	15.7	1.8	14.0	310	1172.0
9/11/2010 15:13	36.5	mid	15.7	1.8	14.0	310	1175.2

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/11/2010 15:15	36.0	mid	15.7	1.8	13.9	310	1172.4
9/11/2010 15:16	35.9	mid	15.7	1.8	13.9	308	1170.4
9/11/2010 15:18	35.8	mid	15.7	1.8	13.9	308	1167.7
9/11/2010 15:20	35.6	mid	15.7	1.8	13.9	302	1164.7
9/11/2010 15:21	36.1	mid	15.7	1.7	13.9	310	1172.4
9/11/2010 15:23	36.2	mid	15.7	1.7	13.9	308	1164.7
9/11/2010 15:25	35.8	mid	15.7	1.7	13.9	305	1161.7
9/11/2010 15:26	36.4	mid	15.7	1.7	13.9	310	1172.4
9/11/2010 15:28	36.6	mid	15.7	1.7	14.0	310	1172.2
9/11/2010 15:30	36.5	mid	15.7	1.7	14.0	313	1172.0
9/11/2010 15:31	36.6	mid	15.7	1.7	14.0	313	1180.7
9/11/2010 15:33	36.3	mid	15.7	1.7	14.0	310	1174.5
9/11/2010 15:35	36.1	mid	15.7	1.7	14.0	305	1163.5
9/11/2010 15:36	36.0	mid	15.7	1.7	14.0	310	1171.5
9/11/2010 15:38	36.5	mid	15.7	1.7	14.0	310	1177.7
9/11/2010 15:40	36.2	mid	15.7	1.7	14.0	310	1171.7
9/11/2010 15:41	36.6	mid	15.7	1.7	14.0	310	1171.7
9/11/2010 15:43	36.1	mid	15.7	1.7	14.0	308	1169.7
9/11/2010 15:45	36.1	mid	15.7	1.7	14.0	310	1168.5
9/11/2010 15:46	36.3	mid	15.7	1.7	14.0	310	1171.5
9/11/2010 15:48	36.1	mid	15.7	1.7	14.0	308	1169.2
9/11/2010 15:50	36.0	mid	15.7	1.7	14.0	305	1160.0
9/11/2010 15:51	36.2	mid	15.7	1.7	14.0	308	1163.0
9/11/2010 15:53	36.0	mid	15.7	1.7	14.0	308	1163.0
9/11/2010 15:55	36.4	mid	15.7	1.7	14.0	308	1170.8
9/11/2010 15:56	36.2	mid	15.7	1.7	14.0	308	1165.8
9/11/2010 15:58	36.1	mid	15.7	1.7	14.0	308	1168.8
9/11/2010 16:00	36.0	mid	15.7	1.7	14.0	308	1162.8
9/11/2010 16:01	35.9	mid	15.7	1.7	14.0	308	1162.8
9/11/2010 16:03	36.1	mid	15.7	1.7	14.0	310	1169.2
9/11/2010 16:05	36.0	mid	15.7	1.8	14.0	310	1171.7
9/11/2010 16:06	36.1	mid	15.7	1.8	14.0	310	1164.0
9/11/2010 16:08	36.1	mid	15.7	1.8	14.0	308	1164.2
9/11/2010 16:10	35.9	mid	15.7	1.8	13.9	305	1164.4
9/11/2010 16:11	36.2	mid	15.7	1.8	13.9	308	1164.4
9/11/2010 16:13	35.9	mid	15.7	1.8	13.9	305	1161.4
9/11/2010 16:15	35.8	mid	15.7	1.8	14.0	308	1158.2

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/11/2010 16:16	35.8	mid	15.7	1.8	14.0	308	1161.2
9/11/2010 16:18	36.5	mid	15.7	1.8	14.0	310	1180.7
9/11/2010 16:20	36.0	mid	15.7	1.7	14.0	305	1169.5
9/11/2010 16:21	36.2	mid	15.7	1.7	14.0	310	1174.5
9/11/2010 16:23	35.8	mid	15.7	1.7	14.0	305	1163.5
9/11/2010 16:25	35.9	mid	15.7	1.7	14.0	308	1160.5
9/11/2010 16:26	36.2	mid	15.7	1.7	14.0	310	1171.7
9/11/2010 16:28	36.4	mid	15.7	1.7	14.0	308	1171.2
9/11/2010 16:30	35.6	mid	15.7	1.7	14.0	302	1157.7
9/11/2010 16:31	35.4	mid	15.7	1.7	14.0	302	1149.7
9/11/2010 16:33	36.5	mid	15.7	1.7	14.0	308	1172.0
9/11/2010 16:35	36.1	mid	15.7	1.7	14.0	308	1170.0
9/11/2010 16:36	36.3	mid	15.7	1.7	14.0	310	1172.0
9/11/2010 16:38	36.2	mid	15.7	1.7	14.0	310	1181.0
9/11/2010 16:40	36.4	mid	15.7	1.7	14.0	310	1171.7
9/11/2010 16:41	36.4	mid	15.7	1.7	14.0	308	1171.7
9/11/2010 16:43	36.0	mid	15.7	1.7	14.0	308	1163.5
9/11/2010 16:45	35.9	mid	15.7	1.7	14.0	308	1169.5
9/11/2010 16:46	36.7	mid	15.7	1.7	14.0	310	1177.5
9/11/2010 16:48	36.6	mid	15.7	1.7	14.0	310	1177.5
9/11/2010 16:50	36.4	mid	15.7	1.7	14.0	310	1174.5
9/11/2010 16:51	36.9	mid	15.7	1.7	14.0	316	1186.5
9/11/2010 16:53	36.2	mid	15.7	1.7	14.0	310	1177.5
9/11/2010 16:55	36.4	mid	15.7	1.7	14.0	308	1166.2
9/11/2010 16:56	36.5	mid	15.7	1.7	14.0	310	1171.2
9/11/2010 16:58	36.5	mid	15.7	1.7	14.0	310	1171.2
9/11/2010 17:00	35.9	mid	15.7	1.7	14.0	308	1163.0
9/11/2010 17:01	36.5	mid	15.7	1.7	14.0	308	1169.0
9/11/2010 17:03	36.1	mid	15.7	1.7	14.0	305	1160.2
9/11/2010 17:05	35.8	mid	15.7	1.7	14.0	302	1151.2
9/11/2010 17:06	35.9	mid	15.7	1.7	14.0	308	1163.2
9/11/2010 17:08	36.2	mid	15.7	1.7	14.0	308	1163.2
9/11/2010 17:10	36.3	mid	15.7	1.7	14.0	310	1174.2
9/11/2010 17:11	36.7	mid	15.7	1.7	14.0	313	1189.0
9/11/2010 17:13	36.3	mid	15.7	1.7	14.0	310	1171.0
9/11/2010 17:15	36.8	mid	15.7	1.7	14.0	313	1180.0
9/11/2010 17:16	36.8	mid	15.7	1.7	14.0	313	1180.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/11/2010 17:18	35.5	mid	15.7	1.7	14.0	308	1163.2
9/11/2010 17:20	36.0	mid	15.7	1.7	14.0	310	1166.5
9/11/2010 17:21	36.4	mid	15.7	1.7	14.0	310	1171.5
9/11/2010 17:23	36.3	mid	15.7	1.7	14.0	310	1169.2
9/11/2010 17:25	36.0	mid	15.7	1.7	14.0	313	1174.2
9/11/2010 17:26	36.2	mid	15.7	1.7	14.0	308	1171.2
9/11/2010 17:28	36.5	mid	15.7	1.7	14.0	313	1180.2
9/11/2010 17:30	36.3	mid	15.7	1.7	14.0	310	1169.2
9/11/2010 17:31	36.6	mid	15.7	1.7	14.0	316	1189.0
9/11/2010 17:33	36.4	mid	15.7	1.7	14.0	310	1171.0
9/11/2010 17:35	36.3	mid	15.7	1.7	14.0	310	1174.0
9/11/2010 17:36	36.1	mid	15.7	1.7	14.0	310	1174.0
9/11/2010 17:38	35.4	mid	15.7	1.7	14.0	302	1160.2
9/11/2010 17:40	36.2	mid	15.7	1.7	14.0	310	1171.2
9/11/2010 17:41	36.1	mid	15.7	1.7	14.0	310	1171.5
9/11/2010 17:43	36.2	mid	15.7	1.7	14.0	310	1171.5
9/11/2010 17:45	36.3	mid	15.7	1.7	14.0	310	1171.7
9/11/2010 17:46	36.8	mid	15.7	1.7	14.0	313	1177.5
9/11/2010 17:48	36.2	mid	15.7	1.7	14.0	313	1180.2
9/11/2010 17:50	36.6	mid	15.7	1.7	14.0	313	1180.2
9/11/2010 17:51	36.2	mid	15.7	1.7	14.0	308	1171.0
9/11/2010 17:53	36.0	mid	15.7	1.7	14.0	310	1173.8
9/11/2010 17:55	36.2	mid	15.7	1.7	14.0	308	1168.8
9/11/2010 17:56	36.2	mid	15.7	1.7	14.0	308	1168.8
9/11/2010 17:58	36.1	mid	15.7	1.7	14.0	305	1159.8
9/11/2010 18:00	35.9	mid	15.7	1.7	14.0	302	1150.8
9/11/2010 18:01	35.5	mid	15.7	1.7	14.0	299	1137.8
9/11/2010 18:03	35.4	mid	15.7	1.7	14.0	299	1143.6
9/11/2010 18:05	35.7	mid	15.7	1.7	14.0	308	1159.6
9/11/2010 18:06	36.1	mid	15.7	1.7	14.0	308	1162.6
9/11/2010 18:08	36.2	mid	15.7	1.7	14.0	308	1162.6
9/11/2010 18:10	36.1	mid	15.7	1.7	14.0	308	1165.8
9/11/2010 18:11	36.6	mid	15.7	1.7	14.0	310	1176.8
9/11/2010 18:13	35.7	mid	15.7	1.7	14.0	302	1150.8
9/11/2010 18:15	36.2	mid	15.7	1.7	14.0	308	1168.8
9/11/2010 18:16	36.9	mid	15.7	1.7	14.0	316	1182.8
9/11/2010 18:18	37.2	mid	15.7	1.7	14.0	313	1185.8

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/11/2010 18:20	36.5	mid	15.7	1.7	14.0	310	1170.8
9/11/2010 18:21	36.4	mid	15.7	1.7	14.0	310	1170.8
9/11/2010 18:23	36.7	mid	15.7	1.7	14.0	313	1179.8
9/11/2010 18:25	36.6	mid	15.7	1.7	14.0	316	1188.8
9/11/2010 18:26	37.2	mid	15.7	1.7	14.0	316	1188.8
9/11/2010 18:28	36.9	mid	15.7	1.7	14.0	313	1177.2
9/11/2010 18:30	36.6	mid	15.7	1.7	14.0	316	1189.7
9/11/2010 18:31	36.3	mid	15.7	1.7	14.0	308	1169.7
9/11/2010 18:33	36.1	mid	15.7	1.7	14.0	310	1164.0
9/11/2010 18:35	36.7	mid	15.7	1.7	14.0	308	1180.7
9/11/2010 18:36	36.4	mid	15.7	1.7	14.0	310	1171.7
9/11/2010 18:38	36.3	mid	15.7	1.7	14.0	308	1169.7
9/11/2010 18:40	36.8	mid	15.7	1.7	14.0	313	1180.7
9/11/2010 18:41	36.6	mid	15.7	1.7	14.0	316	1183.7
9/13/2010 9:21	37.7	control	15.8	1.0	14.7	296	876.1
9/13/2010 9:23	37.4	control	15.8	1.0	14.7	296	875.9
9/13/2010 9:25	37.3	control	15.8	1.0	14.7	294	875.7
9/13/2010 9:26	37.5	control	15.8	1.0	14.7	299	878.7
9/13/2010 9:28	37.0	control	15.8	1.0	14.7	294	873.9
9/13/2010 9:30	36.9	control	15.7	1.0	14.7	294	871.1
9/13/2010 9:31	36.5	control	15.7	1.0	14.7	291	866.3
9/13/2010 9:33	36.4	control	15.7	1.0	14.7	288	797.0
9/13/2010 9:35	36.2	control	15.7	1.0	14.7	291	805.0
9/13/2010 9:36	36.4	control	15.7	1.1	14.6	294	808.0
9/13/2010 9:38	36.2	control	15.7	1.1	14.6	291	802.0
9/13/2010 9:40	36.6	control	15.7	1.1	14.6	294	817.0
9/13/2010 10:06	35.7	mid	15.7	1.1	14.6	285	901.0
9/13/2010 10:08	36.1	mid	15.7	1.1	14.6	288	760.0
9/13/2010 10:10	36.1	mid	15.7	1.1	14.6	288	751.0
9/13/2010 10:11	36.2	mid	15.7	1.1	14.6	291	757.0
9/13/2010 10:13	36.1	mid	15.7	1.1	14.6	291	780.0
9/13/2010 10:15	36.1	mid	15.7	1.1	14.6	288	774.0
9/13/2010 10:16	36.1	mid	15.7	1.1	14.6	288	774.0
9/13/2010 10:18	36.1	mid	15.7	1.1	14.6	291	774.0
9/13/2010 10:20	36.3	mid	15.7	1.1	14.5	291	910.7

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/13/2010 10:21	36.3	mid	15.7	1.1	14.5	291	913.9
9/13/2010 10:23	36.2	mid	15.6	1.1	14.5	291	910.9
9/13/2010 10:25	36.8	mid	15.6	1.1	14.5	296	924.9
9/13/2010 10:26	37.0	mid	15.7	1.1	14.5	296	927.9
9/13/2010 10:28	37.2	mid	15.7	1.1	14.5	299	927.7
9/13/2010 10:30	37.1	mid	15.7	1.1	14.6	294	912.5
9/13/2010 10:31	37.0	mid	15.7	1.1	14.6	296	912.2
9/13/2010 10:33	36.8	mid	15.7	1.1	14.6	299	912.0
9/13/2010 10:35	36.7	mid	15.7	1.1	14.6	299	915.2
9/13/2010 10:36	37.2	mid	15.7	1.1	14.5	299	924.5
9/13/2010 10:38	36.5	mid	15.7	1.1	14.5	294	908.7
9/13/2010 10:40	37.0	mid	15.7	1.1	14.5	296	912.9
9/13/2010 10:41	36.5	mid	15.7	1.1	14.5	294	905.9
9/13/2010 10:43	36.3	mid	15.7	1.1	14.5	291	898.1
9/13/2010 10:45	36.6	mid	15.7	1.1	14.5	294	906.1
9/13/2010 10:46	36.3	mid	15.7	1.1	14.5	294	903.1
9/13/2010 10:48	36.3	mid	15.7	1.2	14.5	294	906.3
9/13/2010 10:50	36.6	mid	15.7	1.2	14.5	296	906.3
9/13/2010 10:51	36.7	mid	15.7	1.2	14.5	296	909.5
9/13/2010 10:53	36.2	mid	15.7	1.2	14.5	291	898.5
9/13/2010 10:55	36.2	mid	15.7	1.1	14.5	294	906.3
9/13/2010 10:56	35.9	mid	15.7	1.1	14.5	291	895.3
9/13/2010 10:58	36.3	mid	15.6	1.1	14.5	294	906.5
9/13/2010 11:00	36.3	mid	15.6	1.2	14.5	294	906.7
9/13/2010 11:01	36.7	mid	15.6	1.2	14.5	296	911.7
9/13/2010 11:03	37.1	mid	15.6	1.2	14.5	299	916.7
9/13/2010 11:05	36.3	mid	15.6	1.2	14.5	294	909.9
9/13/2010 11:06	36.4	mid	15.6	1.2	14.5	294	906.9
9/13/2010 11:08	36.0	mid	15.6	1.2	14.5	291	903.9
9/13/2010 11:10	35.6	mid	15.6	1.2	14.5	288	895.9
9/13/2010 11:11	35.8	mid	15.6	1.2	14.5	291	900.9
9/13/2010 11:13	35.6	mid	15.6	1.2	14.5	285	895.9
9/13/2010 11:15	36.0	mid	15.6	1.2	14.5	291	901.1
9/13/2010 11:16	35.8	mid	15.6	1.2	14.5	288	896.1
9/13/2010 11:18	36.5	mid	15.6	1.2	14.5	294	912.1
9/13/2010 11:20	36.7	mid	15.6	1.2	14.5	296	931.1
9/13/2010 11:21	36.5	mid	15.6	1.2	14.5	296	931.1

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/13/2010 11:23	36.6	mid	15.6	1.2	14.5	296	931.1
9/13/2010 11:25	36.5	mid	15.6	1.2	14.5	294	931.1
9/13/2010 11:26	36.4	mid	15.6	1.2	14.5	296	926.1
9/13/2010 11:28	36.5	mid	15.7	1.2	14.5	296	930.9
9/13/2010 11:30	35.5	mid	15.6	1.2	14.5	291	915.1
9/13/2010 11:31	35.9	mid	15.6	1.2	14.5	294	926.1
9/13/2010 11:33	36.3	mid	15.6	1.2	14.5	294	926.3
9/13/2010 11:35	36.0	mid	15.6	1.2	14.5	294	920.6
9/13/2010 11:36	36.3	mid	15.6	1.2	14.5	294	926.6
9/13/2010 11:38	36.1	mid	15.6	1.2	14.5	291	926.3
9/13/2010 11:40	36.2	mid	15.6	1.2	14.5	294	926.3
9/13/2010 11:41	36.7	mid	15.6	1.2	14.5	296	931.3
9/13/2010 11:43	36.1	mid	15.6	1.2	14.5	291	920.3
9/13/2010 11:45	36.1	mid	15.6	1.2	14.5	294	923.3
9/13/2010 11:46	36.0	mid	15.6	1.2	14.5	291	920.3
9/13/2010 11:48	36.3	mid	15.6	1.2	14.5	296	931.3
9/13/2010 11:50	36.2	mid	15.6	1.2	14.5	296	926.6
9/13/2010 11:51	36.1	mid	15.6	1.2	14.5	291	923.6
9/13/2010 11:53	35.5	mid	15.6	1.2	14.5	288	910.3
9/13/2010 11:55	35.7	mid	15.7	1.2	14.5	288	915.1
9/13/2010 11:56	35.8	mid	15.7	1.2	14.5	288	918.1
9/13/2010 11:58	35.6	mid	15.7	1.2	14.5	288	915.6
9/13/2010 12:00	35.2	mid	15.7	1.2	14.4	285	904.8
9/13/2010 12:01	36.3	mid	15.6	1.2	14.4	294	926.8
9/13/2010 12:03	28.4	mid	15.6	1.2	14.4	232	1200.0
9/13/2010 12:05	26.6	mid	15.6	1.2	14.4	210	1200.0
9/13/2010 12:06	26.6	mid	15.6	1.2	14.4	210	1200.0
9/13/2010 12:08	26.5	mid	15.6	1.2	14.4	210	1199.1
9/13/2010 12:10	26.6	mid	15.7	1.2	14.4	210	1198.3
9/13/2010 12:11	26.6	mid	15.7	1.2	14.4	210	1197.5
9/13/2010 12:13	26.4	mid	15.7	1.2	14.5	210	1196.7
9/13/2010 12:15	26.2	mid	15.7	1.2	14.5	210	1196.7
9/13/2010 12:16	26.4	mid	15.7	1.2	14.5	210	1195.8
9/13/2010 12:18	26.4	mid	15.7	1.2	14.5	210	1195.0
9/13/2010 12:20	26.2	mid	15.6	1.2	14.5	210	1195.8
9/13/2010 12:21	26.8	mid	15.6	1.2	14.5	220	1195.8
9/13/2010 12:23	27.3	mid	15.6	1.2	14.5	230	1195.0

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/13/2010 12:25	27.6	mid	15.6	1.2	14.5	230	1195.8
9/13/2010 12:26	27.8	mid	15.6	1.2	14.4	230	1196.7
9/13/2010 12:28	27.7	mid	15.7	1.2	14.5	230	1196.7
9/13/2010 12:30	27.5	mid	15.6	1.2	14.4	230	1198.3
9/13/2010 12:31	27.8	mid	15.7	1.2	14.4	230	1198.3
9/13/2010 12:33	28.3	mid	15.7	1.2	14.4	238	1197.5
9/13/2010 12:35	28.2	mid	15.6	1.2	14.4	230	1199.1
9/13/2010 12:36	28.4	mid	15.6	1.2	14.4	230	1200.0
9/13/2010 12:38	28.2	mid	15.6	1.2	14.4	230	1200.0
9/13/2010 12:40	28.1	mid	15.7	1.2	14.4	230	1199.1
9/13/2010 12:41	28.1	mid	15.7	1.2	14.4	230	1199.1
9/13/2010 12:43	27.9	mid	15.7	1.2	14.4	230	1198.3
9/13/2010 12:45	27.7	mid	15.7	1.2	14.4	230	1197.5
9/13/2010 12:46	27.8	mid	15.7	1.2	14.5	230	1196.7
9/13/2010 12:48	27.7	mid	15.7	1.2	14.5	230	1195.8
9/13/2010 12:50	27.5	mid	15.7	1.2	14.5	230	1195.0
9/13/2010 12:51	27.4	mid	15.7	1.2	14.5	230	1195.0
9/13/2010 12:53	27.4	mid	15.7	1.2	14.5	230	1195.8
9/13/2010 12:55	27.6	mid	15.7	1.2	14.5	230	1195.8
9/13/2010 12:56	27.7	mid	15.7	1.2	14.5	230	1196.7
9/13/2010 12:58	27.6	mid	15.7	1.2	14.5	230	1196.7
9/13/2010 13:00	27.9	mid	15.7	1.2	14.4	230	1197.5
9/13/2010 13:01	28.8	mid	15.7	1.2	14.4	240	1197.5
9/13/2010 13:03	28.6	mid	15.7	1.2	14.4	240	1199.1
9/13/2010 13:05	28.7	mid	15.7	1.2	14.4	240	1199.1
9/13/2010 13:06	28.5	mid	15.7	1.2	14.4	238	1199.1
9/13/2010 13:08	27.9	mid	15.7	1.2	14.4	230	1199.1
9/13/2010 13:10	28.2	mid	15.7	1.2	14.4	230	1199.1
9/13/2010 13:11	28.0	mid	15.7	1.2	14.4	230	1199.1
9/13/2010 13:13	27.6	mid	15.7	1.2	14.4	230	1199.1
9/13/2010 13:15	27.8	mid	15.7	1.2	14.4	230	1198.3
9/13/2010 13:16	27.5	mid	15.7	1.2	14.4	230	1198.3
9/13/2010 13:18	28.0	mid	15.7	1.2	14.4	230	1198.3
9/13/2010 13:20	28.1	mid	15.7	1.2	14.4	230	1198.3
9/13/2010 13:21	28.0	mid	15.7	1.2	14.4	230	1198.3
9/13/2010 13:23	27.8	mid	15.7	1.2	14.4	230	1199.1
9/13/2010 13:25	27.5	mid	15.7	1.3	14.4	230	1200.8

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/13/2010 13:26	27.5	mid	15.7	1.3	14.4	230	1201.6
9/13/2010 13:28	27.7	mid	15.7	1.3	14.4	230	1201.6
9/13/2010 13:30	27.7	mid	15.7	1.3	14.4	230	1202.5
9/13/2010 13:31	27.8	mid	15.7	1.3	14.4	230	1202.5
9/13/2010 13:33	28.1	mid	15.7	1.3	14.4	230	1203.3
9/13/2010 13:35	27.8	mid	15.7	1.3	14.4	230	1203.3
9/13/2010 13:36	32.5	mid	15.7	1.3	14.4	268	1073.8
9/13/2010 13:38	36.9	mid	15.7	1.3	14.4	308	1024.0
9/13/2010 13:40	37.2	mid	15.7	1.3	14.4	305	1023.8
9/13/2010 13:41	37.3	mid	15.7	1.3	14.4	305	980.8
9/13/2010 13:43	37.3	mid	15.7	1.3	14.4	305	945.0
9/13/2010 13:45	37.1	mid	15.7	1.3	14.4	302	943.2
9/13/2010 13:46	36.8	mid	15.6	1.3	14.4	302	943.2
9/13/2010 13:48	36.9	mid	15.6	1.3	14.4	305	950.4
9/13/2010 13:50	36.4	mid	15.6	1.3	14.3	296	940.9
9/13/2010 13:51	36.6	mid	15.6	1.3	14.3	302	943.9
9/13/2010 13:53	36.5	mid	15.6	1.3	14.3	299	941.1
9/13/2010 13:55	36.7	mid	15.6	1.3	14.3	302	941.5
9/13/2010 13:56	36.9	mid	15.6	1.3	14.3	302	944.3
9/13/2010 13:58	36.7	mid	15.6	1.3	14.3	302	944.3
9/13/2010 14:00	36.9	mid	15.6	1.3	14.3	302	944.1
9/13/2010 14:01	38.2	mid	15.6	1.3	14.3	313	967.9
9/13/2010 14:03	37.7	mid	15.7	1.3	14.4	313	961.7
9/13/2010 14:05	37.3	mid	15.7	1.3	14.4	313	964.4
9/13/2010 14:06	37.8	mid	15.7	1.3	14.4	310	961.4
9/13/2010 14:08	37.9	mid	15.7	1.3	14.4	313	964.2
9/13/2010 14:10	38.1	mid	15.7	1.3	14.4	316	973.4
9/13/2010 14:11	38.0	mid	15.7	1.3	14.4	313	973.4
9/13/2010 14:13	37.2	mid	15.7	1.3	14.4	308	953.4
9/13/2010 14:15	37.0	mid	15.7	1.3	14.3	305	950.9
9/13/2010 14:16	37.3	mid	15.7	1.3	14.3	310	962.1
9/13/2010 14:18	37.7	mid	15.6	1.3	14.3	313	968.7
9/13/2010 14:20	37.6	mid	15.6	1.4	14.3	313	965.9
9/13/2010 14:21	37.3	mid	15.6	1.4	14.3	310	962.9
9/13/2010 14:23	36.6	mid	15.6	1.4	14.3	305	951.9
9/13/2010 14:25	36.9	mid	15.6	1.4	14.3	308	951.9
9/13/2010 14:26	37.5	mid	15.6	1.4	14.3	310	962.9

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/13/2010 14:28	37.0	mid	15.6	1.3	14.3	308	960.5
9/13/2010 14:30	36.7	mid	15.6	1.3	14.3	305	951.7
9/13/2010 14:31	37.4	mid	15.6	1.3	14.3	310	962.5
9/13/2010 14:33	37.3	mid	15.6	1.3	14.3	308	954.3
9/13/2010 14:35	37.2	mid	15.6	1.3	14.3	308	954.1
9/13/2010 14:36	37.1	mid	15.6	1.3	14.3	305	953.9
9/13/2010 14:38	37.3	mid	15.6	1.3	14.3	308	951.1
9/13/2010 14:40	36.8	mid	15.6	1.3	14.3	305	948.1
9/13/2010 14:41	37.1	mid	15.7	1.3	14.3	305	951.1
9/13/2010 14:43	37.1	mid	15.7	1.3	14.3	305	951.1
9/13/2010 14:45	37.0	mid	15.7	1.3	14.3	305	951.1
9/13/2010 14:46	37.2	mid	15.7	1.3	14.3	305	954.3
9/13/2010 14:48	37.1	mid	15.7	1.3	14.3	305	954.3
9/13/2010 14:50	36.9	mid	15.7	1.3	14.3	302	951.5
9/13/2010 14:51	36.8	mid	15.7	1.3	14.3	305	951.5
9/13/2010 14:53	36.7	mid	15.7	1.3	14.3	302	944.5
9/13/2010 14:55	37.0	mid	15.7	1.3	14.3	305	954.3
9/13/2010 14:56	36.9	mid	15.7	1.3	14.3	305	951.3
9/13/2010 14:58	36.8	mid	15.7	1.3	14.3	302	944.3
9/13/2010 15:00	36.8	mid	15.7	1.3	14.3	305	950.9
9/13/2010 15:01	37.7	mid	15.7	1.3	14.3	310	965.1
9/13/2010 15:03	37.6	mid	15.7	1.3	14.3	313	965.3
9/13/2010 15:05	37.5	mid	15.6	1.3	14.3	310	965.5
9/13/2010 15:06	37.5	mid	15.6	1.3	14.3	313	965.5
9/13/2010 15:08	37.1	mid	15.6	1.3	14.3	308	954.7
9/13/2010 15:10	37.0	mid	15.6	1.3	14.3	305	951.7
9/13/2010 15:11	37.1	mid	15.6	1.3	14.3	305	954.7
9/13/2010 15:13	37.7	mid	15.6	1.3	14.3	308	962.7
9/13/2010 15:15	36.6	mid	15.6	1.3	14.3	305	951.7
9/13/2010 15:16	36.9	mid	15.6	1.3	14.3	305	948.5
9/13/2010 15:18	36.8	mid	15.7	1.3	14.3	302	948.3
9/13/2010 15:20	36.6	mid	15.7	1.3	14.3	299	944.3
9/13/2010 15:21	36.6	mid	15.7	1.3	14.3	302	944.3
9/13/2010 15:23	36.9	mid	15.7	1.3	14.3	305	949.3
9/13/2010 15:25	36.9	mid	15.7	1.3	14.3	305	951.3
9/13/2010 15:26	36.5	mid	15.7	1.3	14.3	305	944.3
9/13/2010 15:28	36.9	mid	15.7	1.3	14.3	308	954.5

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/13/2010 15:30	36.7	mid	15.6	1.4	14.3	305	952.1
9/13/2010 15:31	37.7	mid	15.6	1.4	14.3	313	969.3
9/13/2010 15:33	37.6	mid	15.6	1.4	14.3	310	963.5
9/13/2010 15:35	37.5	mid	15.6	1.4	14.3	310	963.5
9/13/2010 15:36	37.8	mid	15.6	1.4	14.3	316	972.5
9/13/2010 15:38	37.4	mid	15.6	1.4	14.3	310	963.5
9/13/2010 15:40	37.3	mid	15.6	1.4	14.3	308	963.5
9/13/2010 15:41	37.0	mid	15.6	1.4	14.3	308	963.8
9/13/2010 15:43	37.0	mid	15.6	1.4	14.3	308	961.5
9/13/2010 15:45	36.2	mid	15.6	1.3	14.3	305	951.9
9/13/2010 15:46	37.4	mid	15.6	1.3	14.3	310	962.9
9/13/2010 15:48	36.7	mid	15.6	1.3	14.3	302	948.7
9/13/2010 15:50	36.7	mid	15.6	1.3	14.3	305	951.9
9/13/2010 15:51	36.7	mid	15.6	1.3	14.3	305	951.9
9/13/2010 15:53	36.6	mid	15.6	1.3	14.3	305	952.3
9/13/2010 15:55	36.9	mid	15.6	1.3	14.3	308	952.3
9/13/2010 15:56	37.0	mid	15.6	1.3	14.3	310	955.3
9/13/2010 15:58	37.1	mid	15.6	1.3	14.3	310	963.5
9/13/2010 16:00	37.4	mid	15.6	1.4	14.3	310	963.5
9/13/2010 16:01	38.2	mid	15.6	1.4	14.3	319	981.5
9/13/2010 16:03	37.8	mid	15.6	1.4	14.3	316	975.3
9/13/2010 16:05	37.8	mid	15.6	1.4	14.3	316	974.9
9/13/2010 16:06	37.7	mid	15.7	1.4	14.3	313	962.7
9/13/2010 16:08	37.3	mid	15.7	1.4	14.3	308	960.5
9/13/2010 16:10	37.4	mid	15.7	1.4	14.3	308	960.3
9/13/2010 16:11	37.1	mid	15.7	1.4	14.3	308	951.3
9/13/2010 16:13	36.7	mid	15.7	1.4	14.3	305	951.5
9/13/2010 16:15	36.7	mid	15.7	1.4	14.3	305	951.7
9/13/2010 16:16	36.6	mid	15.6	1.4	14.3	302	952.1
9/13/2010 16:18	36.4	mid	15.6	1.4	14.3	302	933.5
9/13/2010 16:20	36.5	mid	15.6	1.4	14.2	305	940.0
9/13/2010 16:21	36.5	mid	15.6	1.4	14.3	308	946.0
9/13/2010 16:23	36.4	mid	15.6	1.4	14.3	302	933.8
9/13/2010 16:25	36.4	mid	15.6	1.4	14.3	302	936.8
9/13/2010 16:26	36.6	mid	15.6	1.4	14.3	302	933.8
9/13/2010 16:28	36.8	mid	15.6	1.4	14.3	305	942.8
9/13/2010 16:30	36.9	mid	15.6	1.4	14.3	308	945.5

Appendix Table A-1

Continued.

Date / Time	Power product (MW)	Test / Control	Upstream water level (mNN)	Down stream Water level	Head (m) estimation	Turbine Unit 3 discharge (m^3/s)	Total Station discharge (m^3/s)
9/13/2010 16:31	37.2	mid	15.6	1.4	14.3	308	945.5
9/13/2010 16:33	37.1	mid	15.6	1.4	14.3	308	945.5
9/13/2010 16:35	36.9	mid	15.6	1.4	14.3	305	945.3
9/13/2010 16:36	36.3	mid	15.6	1.4	14.3	305	939.1
9/13/2010 16:38	36.5	mid	15.6	1.4	14.3	302	933.3
9/13/2010 16:40	36.7	mid	15.6	1.4	14.3	302	942.3
9/13/2010 16:41	36.8	mid	15.6	1.3	14.3	305	942.5
9/13/2010 16:43	36.7	mid	15.6	1.3	14.3	308	942.3
	35.7					316	

APPENDIX TABLE B

Appendix Table B-1

Daily tag-recapture data for adult European eels, released through Turbine Unit 3 near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge.

	9/6	9/7	9/8	9/9	9/10	9/11	9/13	Totals
			Tip					
Number released	5	45	--	--	62	--	--	**112**
Number alive	4	42	--	--	60	--	--	**106**
Number recovered dead	0	1	--	--	1	--	--	**2**
Assigned dead	1	2	--	--	0	--	--	**3**
Dislodged tags	1	2	--	--		--	--	**3**
Stationary radio signals	0	0	--	--		--	--	**0**
Undetermined	0	0	--	--	1	--	--	**1**
Held and Alive 1 h	4	42	--	--	60	--	--	**106**
Alive 24 h	4	42	--	--	59	--	--	**105**
Alive 48 h	4	41*	--	--	59	--	--	**104**
			Mid					
Number released	5	--	17	30	--	65	46	**163**
Number alive	5	--	16	29	--	61	44	**155**
Number recovered dead	0	--	0	0	--	0	0	**0**
Assigned dead	0	--	1	1	--	3	2	**7**
Dislodged tags	--	--	1	1	--	3	2	**7**
Stationary radio signals	--	--	0	0	--	0	0	**0**
Undetermined	0	--	0	0	--	0	0	**0**
Held and Alive 1 h	5	--	16	29	--	61	44	**155**
Alive 24 h	5	--	15	29	--	58	43	**150**
Alive 48 h	5	--	15	29	--	56*	43	**148**
			Controls					
Number released	5	1	2	20	7	10	5	**50**
Number alive	5	1	2	20	7	10	5	**50**
Number recovered dead	0	0	0	0	0	0	0	**0**
Assigned dead	0	0	0	0	0	0	0	**0**
Dislodged tags	--	--	--	--	--	--	--	**0**
Stationary radio signals	--	--	--	--	--	--	--	**0**
Undetermined	0	0	0	0	0	0	0	**0**
Held and Alive 1 h	5	1	2	20	7	10	5	**50**
Alive 24 h	5	1	2	20	7	10	5	**50**
Alive 48 h	5	1	2	20	7	10	5	**50**

* One fish classified as functionally dead at 48 h assessment, likely not capable of migrating to ocean.

Appendix Table B-2

Daily malady data for adult European eels, released through Turbine Unit 3 near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge.

	9/6	9/7	9/8	9/9	9/10	9/11	9/13	Totals
				Tip				
Number released	5	45	--	--	62	--	--	**112**
Number examined	4	43	--	--	61	--	--	**108**
Passage related maladies	0	4	--	--	6	--	--	**10**
Visible injuries	--	4	--	--	4	--	--	**8**
Loss of equilibrium only	--	0	--	--	2	--	--	**2**
Without maladies	4	39	--	--	55	--	--	**98**
Without maladies that died	0	0	--	--	0	--	--	**0**
				Mid				
Number released	5	--	17	30	--	65	46	**163**
Number examined	5	--	16	29	--	61	44	**155**
Passage related maladies	0	--	1	1	--	7	3	**12**
Visible injuries	--	--	1	1	--	5	3	**10**
Loss of equilibrium only	--	--	0	0	--	2	0	**2**
Without maladies	5	--	15	28	--	54	41	**143**
Without maladies that died	0	--	0	0	--	0	0	**0**
				Controls				
Number released	5	1	2	20	7	10	5	**50**
Number examined	5	1	2	20	7	10	5	**50**
Passage related maladies	0	0	0	0	0	0	0	**0**
Visible injuries	--	--	--	--	--	--	--	**0**
Loss of equilibrium only	--	--	--	--	--	--	--	**0**
Without maladies	5	1	2	20	7	10	5	**50**
Without maladies that died	0	0	0	0	0	0	0	**0**

Appendix Table B-3

Daily 48 h survival/malady free data observed on adult European eels released through Turbine Unit 3 near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge.

	9/6	9/7	9/8	9/9	9/10	9/11	9/13	Totals
				Tip				
Number released	5	45	--	--	62	--	--	**112**
Number examined	4	43	--	--	61	--	--	**108**
Number alive and malady free	4	39	--	--	55	--	--	**98**
Maladies / died	0	4	--	--	6	--	--	**10**
Number assigned dead	1	2	--	--	0	--	--	**3**
Undetermined	0	0	--	--	1	--	--	**1**
				Mid				
Number released	5	--	17	30	--	65	46	**163**
Number examined	5	--	16	29	--	61	44	**155**
Number alive and malady free	5	--	15	28	--	54	41	**143**
Maladies / died	0	--	1	1	--	7	3	**12**
Number assigned dead	0	--	1	1	--	3	2	**7**
Undetermined	0	--	0	0	--	1	0	**1**
				Controls				
Number released	5	1	2	20	7	10	5	**50**
Number examined	5	1	2	20	7	10	5	**50**
Number alive and malady free	5	1	2	20	7	10	5	**50**
Maladies / died	0	0	0	0	0	0	0	**0**
Number assigned dead	0	0	0	0	0	0	0	**0**
Undetermined	0	0	0	0	0	0	0	**0**

Appendix Table B-4

Summary of alive at 48 h and malady-free data for adult European eels released through Turbine Unit 3 near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge.

	Turbine Unit 3		Controls
	Tip	Mid	
Number released	112	163	50
Number examined for injuries	108	155	50
Alive and malady free	98	143	50
With maladies, or died	10	12	0
Number assigned dead	3	7	0
Undetermined	1	1	0

APPENDIX TABLE C

Appendix C

One hour survival estimates for combined adult European eels, including functionally dead eels (not capable of migrating to the ocean) released through Turbine Unit 3, at two depths near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge. Combined control fish released 50, 50 alive and 0 dead; Combined treatment: 275 released, 261 alive and 12 assigned dead.

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	0.9938	(0.0043)	Recovery probability
Tau =	**0.9560**	**(0.0124)**	**Treatment survival**
1-Tau =	0.0440	(0.0124)	Treatment mortality

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.
log-likelihood : -61.402283

Variance-Covariance matrix for estimated probabilities:
0.00002 0.00000
0.00000 0.00015

Profile likelihood intervals:

	Treatment survival	Treatment mortality
90 percent:	(0.9326, 0.9735)	(0.0265, 0.0674)
95 percent:	(0.9274, 0.9762)	(0.0238, 0.0726)
99 percent:	(0.9166, 0.9809)	(0.0191, 0.0834)

==========

Likelihood ratio statistic for equality of recovery probabilities: 0.670464
Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

One hour survival estimates for adult European eels, released through Turbine Unit 3, at two depths near blade tip (shallow) and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge. Combined control fish released 50, 50 alive and 0 dead; Shallow: 112 released, 106 alive and 5 assigned dead. Mid: 163 released, 155 alive and 7 assigned dead.

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S1 =	1.0	N/A	Control group survival*
Pa = Pd	0.9938	(0.0043)	Recovery probability
S2 =	0.9550	(0.0197)	Shallow survival
S3 =	0.9568	(0.0160)	Mid survival

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.
log-likelihood : -61.3997

Tau = 0.9550 (0.0197) Shallow/Control ratio
Tau = 0.9568 (0.0160) Mid/Control ratio

Z statistic for the equality of equal turbine survivals: 0.0724

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00001882	0.00000000	0.00000000
0.00000000	0.00000000	0.00038753	0.00000000
0.00000000	0.00000000	0.00000000	0.00025520

Confidence intervals:

	Shallow Tau	Mid Tau
90 percent:	(0.9226, 0.9873)	(0.9305, 0.9831)
95 percent:	(0.9164, 0.9935)	(0.9255, 0.9881)
99 percent:	(0.9043, 1.0056)	(0.9157, 0.9979)

==========

Likelihood ratio statistic for equality of recovery probabilities: 0.6928
Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Forty-eight hour survival estimates for combined adult European eels, including functionally dead eels (not capable of migrating to the ocean) released through Turbine Unit 3, at two depths near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge. Combined control fish released 50, 50 alive and 0 dead; Combined treatment including functionally dead: 275 released, 252 alive and 21 assigned dead.

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	0.9938	(0.0043)	Recovery probability
Tau =	**0.9231**	**(0.0161)**	**Treatment survival**
1-Tau =	0.0769	(0.0161)	Treatment mortality

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.
log-likelihood : -86.209888

Variance-Covariance matrix for estimated probabilities:
0.00002 0.00000
0.00000 0.00026

Profile likelihood intervals:

	Treatment survival	Treatment mortality
90 percent:	(0.8938, 0.9468)	(0.0532, 0.1062)
95 percent:	(0.8875, 0.9508)	(0.0492, 0.1125)
99 percent:	(0.8747, 0.9579)	(0.0421, 0.1253)

==========

Likelihood ratio statistic for equality of recovery probabilities: 0.670464
Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Forty-eight hour survival estimates for combined adult European eels, released through Turbine Unit 3, at two depths near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge. Combined control fish released 50, 50 alive and 0 dead; Combined treatment: 275 released, 254 alive and 19 assigned dead.

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group survival*
Pa = Pd	0.9938	(0.0043)	Recovery probability
Tau =	**0.9304**	**(0.0154)**	**Treatment survival**
1-Tau =	0.0696	(0.0154)	Treatment mortality

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.
log-likelihood : -81.133745

Variance-Covariance matrix for estimated probabilities:
0.00002 -0.00000
-0.00000 0.00024

Profile likelihood intervals:

	Treatment survival	Treatment mortality
90 percent:	(0.9022, 0.9529)	(0.0471, 0.0978)
95 percent:	(0.8962, 0.9566)	(0.0434, 0.1038)
99 percent:	(0.8838, 0.9632)	(0.0368, 0.1162)

==========

Likelihood ratio statistic for equality of recovery probabilities: 0.670464
Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

==========

Appendix C

Forty-eight hour survival estimates for adult European eels, including functionally dead eels (not capable of migrating to the ocean) released through Turbine Unit 3, at two depths near blade tip (shallow) and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge. Combined control fish released 50, 50 alive and 0 dead; Shallow: 112 released, 104 alive and 7 assigned dead; Mid: 163 released, 148 alive and 14 assigned dead.

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S1 =	1.0	N/A	Control group survival*
Pa = Pd	0.9938	(0.0043)	Recovery probability
S2 =	0.9369	(0.0231)	Shallow survival
S3 =	0.9136	(0.0221)	Mid survival

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.
log-likelihood : -85.9514

Tau = 0.9369 (0.0231) Shallow/Control ratio
Tau = 0.9136 (0.0221) Mid/Control ratio

Z statistic for the equality of equal turbine survivals: 0.7314

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00001882	0.00000000	0.00000000
0.00000000	0.00000000	0.00053231	0.00000000
0.00000000	0.00000000	0.00000000	0.00048735

Confidence intervals:

	Shallow Tau	Mid Tau
90 percent:	(0.8990, 0.9749)	(0.8773, 0.9499)
95 percent:	(0.8917, 0.9822)	(0.8703, 0.9568)
99 percent:	(0.8775, 0.9963)	(0.8567, 0.9704)

==========

Likelihood ratio statistic for equality of recovery probabilities: 0.5270
Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Forty-eight hour survival estimates for adult European eels, released through Turbine Unit 3, at two depths near blade tip (shallow) and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge. Combined control fish released 50, 50 alive and 0 dead; Shallow: 112 released, 105 alive and 6 assigned dead. Mid: 163 released, 149 alive and 13 assigned dead.

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S1 =	1.0	N/A	Control group survival*
Pa = Pd	0.9938	(0.0031)	Recovery probability
S2 =	0.9459	(0.0148)	Shallow survival
S3 =	0.9198	(0.0213)	Mid survival

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.
log-likelihood : -80.7749

Tau = 0.9459 (0.0178) Shallow/Control ratio
Tau = 0.9198 (0.0211) Mid/Control ratio

Z statistic for the equality of equal turbine survivals: 0.9494

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

-0.00001446	0.00001137	-0.00005913	0.00000000
0.00001137	0.00000988	0.00004649	0.00000000
-0.00005913	0.00004649	0.00021882	0.00000000
0.00000000	0.00000000	0.00000000	0.00045560

Confidence intervals:

	Shallow Tau	Mid Tau
90 percent:	(0.9166, 0.9753)	(0.8851, 0.9544)
95 percent:	(0.9110, 0.9809)	(0.8785, 0.9610)
99 percent:	(0.9000, 0.9918)	(0.8655, 0.9740)

==========

Likelihood ratio statistic for equality of recovery probabilities: 0.4789
Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Malady-free rates for combined adult European eels, released through Turbine Unit 3, at two depths near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge. Combined Control fish examined: 50; 50 alive no maladies and 0 with maladies; combine treatment: 263 examined, 241 alive no maladies and 22 with maladies.

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S =	1.0	N/A	Control group malady-free rate*
Pa = Pd	1.0	N/A	Recovery probability*
Tau =	**0.9163**	**(0.0171)**	**Treatment malady-free rate**
1-Tau =	0.0837	(0.0171)	Treatment mortality

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.
log-likelihood : -75.637516

Variance-Covariance matrix for estimated probabilities:
0.00029

Profile likelihood intervals:

	Treatment malady-free rate	Treatment mortality
90 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
95 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)
99 percent:	(0.0000, 1.0000)	(0.0000, 1.0000)

==========

Likelihood ratio statistic for equality of recovery probabilities: 0.000000
Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Malady-free rates for adult European eels, released through Turbine Unit 3, at two depths near blade tip (shallow) and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge. Combined Control fish examined: 50; 50 alive no maladies and 0 with maladies; Shallow treatment: 108 examined, 98 alive no maladies and 10 with maladies; Mid treatment: 155 examined, 143 alive no maladies and 12 with maladies.

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std.err.	
S1 =	1.0	N/A	Control group malady-free rate*
Pa = Pd	1.0	N/A	Recovery probability*
S2 =	0.9074	(0.0279)	Shallow malady-free rate
S3 =	0.9226	(0.0215)	Mid malady-free rate

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.
log-likelihood : -75.5428

Tau = 0.9074 (0.0279) Shallow/Control ratio
Tau = 0.9226 (0.0215) Mid/Control ratio

Z statistic for the equality of equal turbine malady-free rates: 0.4304

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00000001	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00077780	0.00000000
0.00000000	0.00000000	0.00000000	0.00046084

Confidence intervals:

	Shallow Tau	Mid Tau
90 percent:	(0.8616, 0.9533)	(0.8873, 0.9579)
95 percent:	(0.8528, 0.9621)	(0.8805, 0.9647)
99 percent:	(0.8356, 0.9792)	(0.8673, 0.9779)

==========

Likelihood ratio statistic for equality of recovery probabilities: 0.0000
Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

APPENDIX TABLE D

Appendix Table D

Short term passage survival data for adult European eels released through Turbine Unit 3 near blade tip and near mid blade and discharging approximately 300 m^3/s at Beaucaire Dam, France, September 2010. Controls released into the tailrace discharge.

Fish ID	Total Length (mm)	Time Released	Time Recovered	Minutes at large	No. HI-Z tags recovered	Survival Code	Status Codes 1	2	3	4
6-Sep-10		**Testlot 1**			**Water temp = 23.5°C**					
				Tip						
661	620	17:33	17:36	*3*	4	1 A				
662	660	17:53	17:56	*3*	3	1 A				
663	660	18:01			3	3				
664	780	18:07	18:09	*2*	5	1 A				
665	660	18:13	18:17	*4*	3	1 A				
666	730	10:00	10:06	*6*	5	1 A				
667	700	10:08	10:12	*4*	4	1 B				
668	610	10:22	10:24	*2*	4	1 A				
669	740	10:29	10:34	*5*	6	1 A				
670	660	10:41			2	3				
6-Sep-10		**Testlot 1**			**Water temp = 23.5°C**					
				Mid						
656	750	16:15	16:17	*2*	5	1 A				
657	770	16:24	16:27	*3*	5	1 4				
658	630	16:33	16:35	*2*	4	1 A				
659	760	16:43	16:57	*14*	5	1 A				
660	770	16:51	16:59	*8*	4	1 A				
6-Sep-10		**Testlot 1**			**Water temp = 23.5°C**					
				Controls						
651	730	14:13	14:17	*4*	5	1 A				
652	750	14:35	14:41	*6*	5	1 A				
653	600	14:52	15:19	*27*	4	1 T	A			
654	690	15:18	15:20	*2*	4	1 A				
655	650	15:34	15:49	*15*	4	1 A				
7-Sep-10		**Testlot 2**			**Water temp = 22.5°C**					
				Tip						
671	650	10:48	10:52	*4*	4	1 A				
672	690	11:07	11:14	*7*	4	1 A				
673	660	11:17	11:19	*2*	4	1 A				
674	780	11:24	11:28	*4*	6	1 A				
675	700	11:32	11:37	*5*	3	2 *	6			
676	640	11:38	11:43	*5*	4	1 A				
677	710	11:45	11:48	*3*	5	1 A				
678	720	11:52	11:54	*2*	5	1 A				
679	630	13:46	13:48	*2*	4	1 A				
680	620	13:52	14:09	*17*	4	1 T	E			
681	600	14:14	14:23	*9*	4	1 T	A			
682	760	14:20	14:22	*2*	6	1 A				
683	770	14:28	14:39	*11*	6	1 A	T			
684	750	14:34	14:38	*4*	5	1 A				
685	790	14:41	14:44	*3*	6	1 A				
686	670	14:48	14:51	*3*	5	1 A				

Appendix Table D

Continued.

Fish ID	Total Length (mm)	Time Released	Time Recovered	Minutes at large	No. HI-Z tags recovered	Survival Code	Status Codes 1	2	3	4
687	720	14:53	14:56	*3*	4	1 *	G			
688	710	15:00	15:02	*2*	5	1 A				
689	710	15:06	15:10	*4*	3	1 A				
690	600	15:21	15:23	*2*	4	1 A				
691	630	15:31	15:41	*10*	4	1 T	A			
692	600	15:39	15:42	*3*	4	1 A				
693	710	15:45	15:50	*5*	5	1 A				
694	640	15:56	15:58	*2*	4	1 A				
695	600	16:15	16:19	*4*	4	1 A				
696	610	16:26	16:29	*3*	4	1 A				
697	660	16:33	16:40	*7*	3	1 T	A			
698	740	16:42	16:45	*3*	5	1 A				
699	640	16:52	16:54	*2*	4	1 A				
700	640	16:59			3	3				
624	640	17:14	17:16	*2*	4	1 A				
625	640	17:14	17:16	*2*	5	1 A				
626	760	17:19	17:22	*3*	5	1 A				
627	620	17:30	17:33	*3*		1 A				
628	770	17:35	17:39	*4*	3	1 A				
629	650	17:41	17:44	*3*	5	1 *	H	4		
630	650	17:46	17:54	*8*	5	1 A				
631	740	17:52	17:55	*3*	5	1 A				
632	700	17:59	18:11	*12*	6	1 T	A			
633	630	18:05	18:07	*2*	2	1 *	G	H		
	7-Sep-10	**Testlot 2**			**Water temp = 22.5°C**					
				Controls						
634	730	18:45	18:50	*5*	5	1 T	A			
	8-Sep-10	**Testlot 3**			**Water temp = 22.5°C**					
				Mid						
601	600	16:09	16:11	*2*	5	1 *	4	H	G	
602	780	16:21	16:27	*6*	5	1 A				
603	610	16:32	16:34	*2*	4	1 A				
604	610	16:41	16:43	*2*	4	1 A				
605	650	16:47	16:49	*2*	4	1 A				
606	630	16:54	16:58	*4*	4	1 A				
607	650	17:01	17:04	*3*	4	1 A				
608	640	17:09			3	3				
609	700	17:13	17:16	*3*	4	1 A				
610	700	17:20	18:32	*72*	5	1 T	A			
611	650	17:27	17:31	*4*	4	1 A				
626	610	17:54	18:02	*8*	4	1 A				
627	740	18:02	18:05	*3*	3	1 A				
628	700	18:08	18:11	*3*	5	1 A				
629	700	18:14	18:18	*4*	6	1 A	T			
630	580	18:20	18:29	*9*	4	1 A				
631	740	18:38	18:41	*3*	3	1 A				
	8-Sep-10	**Testlot 3**			**Water temp = 22.5°C**					
				Controls						
612	800	14:47	14:58	*11*	1	1 A				
613	760	15:00			0	5 K				R

Appendix Table D

Continued.

Fish ID	Total Length (mm)	Time			No. HI-Z tags recovered	Survival Code	Status Codes			
		Released	Recovered	Minutes at large			1	2	3	4
614	590	15:24	15:27	*3*	4	1	A			
9-Sep-10		**Testlot 4**			**Water temp = 19.0°C**					
				Mid						
632	600	9:29	9:31	*2*	4	1	A			
633	770	9:36	9:40	*4*	6	1	A			
634	620	9:56	10:00	*4*	4	1	A			
635	710	10:07	10:10	*3*	5	1	A			
636	810	10:15	10:18	*3*	5	1	A			
637	580	10:23	10:25	*2*	1	1	A			
638	650	10:28	10:31	*3*	4	1	A			
639	700	10:35	10:38	*3*	5	1		V	M	
640	810	10:41	10:44	*3*	6	1	A			
641	660	10:52	10:56	*4*	5	1	A			
642	780	10:58	11:00	*2*	6	1	A			
643	650	11:04	11:05	*1*	3	1	A			
644	620	11:11	11:17	*6*	3	1	A			
645	630	11:19	11:22	*3*	5	1	A			
646	700	11:29			2	3				
647	620	11:35	11:38	*3*	4	1	A			
648	810	11:45	11:48	*3*	6	1	A			
649	710	13:41	13:47	*6*	5	1	A			
801	680	13:47	13:52	*5*	5	1	A			
802	630	13:56	13:58	*2*	2	1	*	J	H	G
803	650	14:04	14:06	*2*	4	1	A			
804	790	14:11	14:15	*4*	6	1	A			
805	750	14:18	14:20	*2*	6	1	A			
806	630	14:25	14:28	*3*	3	1	A			
807	640	14:31	14:33	*2*	4	1	A			
808	740	14:37	14:39	*2*	4	1	A			
809	620	14:42	14:45	*3*	4	1	A			
810	640	14:48	14:50	*2*	4	1	A			
811	640	14:52	14:54	*2*	4	1	A			
812	740	14:58	15:01	*3*	5	1	A			
9-Sep-10		**Testlot 4**			**Water temp = 19.0°C**					
				Controls						
813	760	15:24	15:28	*4*	5	1	A			
814	660	15:30	15:33	*3*	5	1	A			
815	660	15:35	15:48	*13*	4	1	T	A		
816	640	15:41	15:43	*2*	5	1	A			
817	900	15:55	16:00	*5*	6	1	A			
818	680	16:01	16:04	*3*	5	1	A			
819	810	16:10	16:13	*3*	5	1	A			
820	610	16:14	16:20	*6*	4	1	A			
821	710	16:21	16:25	*4*	5	1	A			
822	670	16:27	16:31	*4*	5	1	A			
823	610	16:34	16:36	*2*	4	1	A			
824	810	16:40			0	5	R			
825	840	16:48	16:51	*3*	6	1	A			
826	590	17:00	17:05	*5*	4	1	A			
827	690	17:07	17:09	*2*	4	1	A			

Appendix Table D

Continued.

Fish ID	Total Length (mm)	Time Released	Time Recovered	Minutes at large	No. HI-Z tags recovered	Survival Code	Status Codes 1	2	3	4
828	590	17:12	17:14	*2*	4	1	A			
829	810	17:12	17:31	*19*	6	1	T	A		
830	740	17:27	17:44	*17*	4	1	T	A		
831	830	17:40	17:42	*2*	6	1	A			
832	600	17:45	17:48	*3*	4	1	A			
833	680	17:52	17:59	*7*	4	1	T	A		
	10-Sep-10	**Testlot 5**			**Water temp = 20.0°C**					
				Tip						
834	650	8:44	8:46	*2*	4	1	A			
835	630	8:49	8:52	*3*	4	1	A			
836	630	8:54	8:57	*3*	.	1	A			
837	700	9:00	9:08	*8*	5	1	A			
838	640	9:04	9:07	*3*	4	1	A			
839	690	9:11	9:14	*3*	5	1	A			
840	710	9:17	9:21	*4*	3	1	A			
841	600	9:25	9:28	*3*	4	1	A			
842	760	9:33	9:37	*4*	6	1	A			
843	690	9:38	9:40	*2*	5	1	A			
844	670	9:44	9:47	*3*	5	1	A			
845	650	9:50	9:57	*7*	4	1	A			
846	650	9:55	9:59	*4*	4	1	*	H	G	
847	760	10:02	10:05	*3*	4	1	*	H	G	
848	660	10:08	10:11	*3*	4	1	A			
849	660	10:12	10:16	*4*	4	1	A			
850	730	10:18	10:22	*4*	5	1	A			
851	620	10:25	10:28	*3*	4	1	A			
852	720	10:32	10:36	*4*	5	1	A			
853	630	10:37	10:41	*4*	2	1	A			
854	640	10:45	10:48	*3*	4	1	A			
855	690	10:58			0	4				
856	700	11:04	11:12	*8*	4	1	*	G		
857	810	11:10	11:18	*8*	4	1	*	H	J	
858	670	11:24	11:31	*7*	4	1	A			
859	740	11:35	11:38	*3*	6	1	A			
860	690	11:41	11:44	*3*	5	1	A			
861	690	11:45	11:50	*5*	4	1	A			
862	690	13:45	13:49	*4*	5	1	A			
863	680	13:55	13:57	*2*	5	1	A			
864	630	14:01	14:21	*20*	4	1	T	A		
865	670	14:07	14:10	*3*	2	1	A			
866	620	14:13	14:17	*4*	4	1	A			
867	630	14:18	14:24	*6*	4	1	A			
868	770	14:24	14:29	*5*	6	1	A			
869	840	14:36	14:41	*5*	6	1	A			
870	760	14:41	14:45	*4*	6	1	A			
871	730	14:47	14:50	*3*	6	1	A			
872	670	14:51	14:56	*5*	3	2	*	6		
873	750	14:58	15:01	*3*	6	1	A			
874	660	15:06	15:08	*2*	5	1	A			
875	780	15:11	15:14	*3*	6	1	A			

Appendix Table D

Continued.

Fish ID	Total Length (mm)	Time Released	Time Recovered	Minutes at large	No. HI-Z tags recovered	Survival Code	Status Codes 1	2	3	4
876	650	15:17	15:20	*3*	3	1	*	J	H	
877	650	15:23	15:26	*3*	4	1	A			
878	600	15:27	15:34	*7*	4	1	A			
879	630	15:30	15:35	*5*	4	1	A			
880	760	15:43	15:47	*4*	5	1	A			
881	750	15:48	15:52	*4*	5	1	A			
882	730	15:54	15:58	*4*	6	1	A			
883	580	16:00	16:04	*4*	4	1	A			
884	640	16:31	16:34	*3*	4	1	A			
885	760	16:37	16:39	*2*	4	1	A			
886	840	16:41	16:45	*4*	6	1	A			
887	620	16:47	16:50	*3*	4	1	A			
888	660	16:53	16:56	*3*	4	1	A			
889	580	17:00	17:02	*2*	4	1	A			
890	610	17:05	17:07	*2*	4	1	A			
891	660	17:08	17:11	*3*	4	1	A			
892	860	17:14	17:18	*4*	6	1	A			
893	999	17:20	17:24	*4*	6	1	A			
894	630	17:25	17:28	*3*	4	1	A			
895	610	17:31	17:35	*4*	4	1	A			
	10-Sep-10	**Testlot 5**			**Water temp = 20.0°C**					
				Controls						
896	700	18:06	18:29	*23*	5	1	T	A		
897	620	18:11	18:15	*4*	4	1	A			
898	680	18:16	18:23	*7*	5	1	A			
899	620	18:27	18:32	*5*	4	1	A			
900	700	18:34	18:37	*3*	5	1	A			
943	670	18:40	18:44	*4*	5	1	A			
944	870	18:48	18:53	*5*	6	1	A			
	11-Sep-10	**Testlot 6**			**Water temp = 20.0°C**					
				Mid						
905	780	9:52	9:57	*5*	6	1	A			
906	740	9:59	10:03	*4*	5	1	A			
907	730	10:06	10:14	*8*	4	1	A			
908	700	10:14	10:19	*5*	3	1	A			
909	620	10:18	10:22	*4*	4	1	A			
910	710	10:26			3	3				
911	680	10:32	10:35	*3*	4	1	A			
912	620	10:36			2	3				
913	680	10:42	10:45	*3*	5	1	A			
914	660	10:46	10:50	*4*	5	1	A			
915	730	11:10	11:13	*3*	6	1	A			
916	670	11:14	11:17	*3*	5	1	A			
917	640	11:18	11:21	*3*	4	1	A			
918	650	11:23	11:27	*4*	4	1	A			
919	750	11:28	11:37	*9*	6	1	A			
920	770	11:33	11:37	*4*	6	1	A			
921	740	11:39			6	3				
922	780	11:45	11:48	*3*	4	1	A			
923	670	11:50	11:54	*4*	4	1	A			

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Continued.

Fish ID	Total Length (mm)	Time Released	Time Recovered	Minutes at large	No. HI-Z tags recovered	Survival Code	Status Codes 1	2	3	4
924	670	11:56	12:00	*4*	4	1	A			
925	600	13:48	13:51	*3*	3	1	A			
926	600	13:53	13:56	*3*	4	1	A			
927	640	13:58	14:02	*4*	4	1	A			
928	720	14:05	14:07	*2*	6	1	A			
929	670	14:10	14:16	*6*	1	1	*	G		
930	700	14:17	14:19	*2*	6	1	A			
931	680	14:22	14:28	*6*	6	1	A			
932	650	14:27	14:32	*5*	4	1	A			
933	590	14:33	14:38	*5*	4	1	A			
934	600	14:39	14:42	*3*	4	1	A			
935	650	14:44	14:58	*14*	4	1	A			
936	640	14:48	14:50	*2*	4	1	A			
937	720	14:56	15:00	*4*	6	1	A			
938	700	15:02	15:06	*4*	6	1	A			
939	800	15:10	15:15	*5*	5	1	A			
940	650	15:15	15:21	*6*	5	1	*	H		
941	590	15:20	15:24	*4*	4	1	A			
942	640	15:24	15:27	*3*	4	1	A			
943	690	15:29	15:33	*4*	4	1	A			
944	630	15:35	15:41	*6*	4	1	A			
1	610	15:58	16:00	*2*	4	1	A			
2	740	16:03	16:07	*4*	4	1	A			
3	620	16:08	16:11	*3*	4	1	*	H	J	G
4	700	16:13	16:16	*3*	6	1	A			
5	530	16:20	16:24	*4*	4	1	A			
6	640	16:25	16:27	*2*	4	1	A			
951	570	16:31	16:35	*4*	1	1	*	H		
952	710	16:38	16:40	*2*	6	1	A			
953	640	16:42	16:44	*2*	4	1	A			
954	640	16:46	16:49	*3*	4	1	A			
955	640	16:51	16:54	*3*	4	1	A			
956	620	16:56			0	4				
957	590	17:01	17:04	*3*	4	1	A			
958	640	17:05	17:08	*3*	4	1	A			
959	810	17:11	17:13	*2*	5	1	A	*		
960	680	17:17	17:26	*9*	6	1	A	T		
961	640	17:22	17:27	*5*	4	1	A			
962	620	17:27	17:30	*3*	4	1	A			
963	620	17:34	17:37	*3*	4	1	A			
964	670	17:41	17:44	*3*	4	1	*	E		
965	530	18:12	18:14	*2*	4	1	A			
966	770	18:22	18:24	*2*	6	1	A			
967	830	18:27	18:32	*5*	6	1	A			
968	820	18:33	18:41	*8*	6	1	A			
969	790	18:38	18:41	*3*	6	1	A			
11-Sep-10		**Testlot 6**			**Water temp = 20.0°C**					
				Controls						
945	660	8:36	8:40	*4*	4	1	A			
946	780	8:42	8:46	*4*	5	1	A			

Appendix Table D

Continued.

Fish ID	Total Length (mm)	Time Released	Time Recovered	Minutes at large	No. HI-Z tags recovered	Survival Code	Status Codes 1	2	3	4
947	690	8:50	8:54	*4*	4	1	A			
948	680	8:55	8:57	*2*	5	1	A			
949	790	9:07	9:22	*15*	5	1	A			
950	620	9:00	9:04	*4*	4	1	A			
901	660	9:11	9:17	*6*	4	1	A			
902	620	9:15	9:20	*5*	4	1	A			
903	780	9:21	9:24	*3*	5	1	A			
904	680	9:25	9:29	*4*	4	1	A			
	13-Sep-10	**Testlot 7**			**Water temp = 21.0°C**					
				Mid						
376	850	10:07	10:10	*3*	6	1	A			
377	800	10:11	10:15	*4*	6	1	A			
378	700	10:16			4	3				
379	690	10:21	13:38	*197*	4	1	A			
380	590	10:26	10:57	*31*	4	1	T	A		
381	610	10:32	10:40	*8*	4	1	*	H		
382	640	11:03	11:10	*7*	6	1	A			
383	690	11:06	11:11	*5*	6	1	A			
384	730	11:11	11:14	*3*	6	1	A			
385	620	11:24	11:26	*2*	4	1	A			
386	520	11:28	11:30	*2*	4	1	A			
387	770	11:35	11:37	*2*	6	1	A			
388	650	11:40	11:42	*2*	6	1	A			
389	690	11:45	11:47	*2*	6	1	A			
390	750	11:50	11:51	*1*	6	1	A			
391	660	11:55	11:58	*3*	6	1	A			
392	740	13:48	13:49	*1*	4	1	*	H	G	4
393	630	13:54	13:56	*2*	4	1	A			
394	690	13:59	14:14	*15*	4	1	A			
395	680	14:06	14:08	*2*	4	1	A			
396	650	14:13	14:19	*6*	4	1	A			
397	630	14:21	14:24	*3*	4	1	A			
398	680	14:29	14:31	*2*	6	1	A			
399	600	14:33	14:37	*4*	4	1	A			
400	770	14:42	14:43	*1*	4	1	A			
976	630	14:49	14:52	*3*	4	1	A			
977	740	14:54	14:57	*3*	6	1	A			
978	650	14:59	15:36	*37*	3	1	A			
979	610	15:04	15:07	*3*	4	1	A			
980	620	15:09	15:11	*2*	4	1	A			
981	640	15:14	15:18	*4*	4	1	A			
982	810	15:18	15:21	*3*	6	1	A			
983	790	15:23	15:25	*2*	6	1	*	4		
984	640	15:29	15:31	*2*	4	1	A			
985	620	15:38	15:44	*6*	4	1	A			
986	650	15:45	15:47	*2*	6	1	A			
987	760	15:50	15:54	*4*	6	1	A			
988	710	15:56	16:00	*4*	6	1	A			
989	720	16:01			4	3				
990	790	16:05	16:13	*8*	5	1	A			

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Continued.

Fish ID	Total Length (mm)	Time			No. HI-Z tags recovered	Survival Code	Status Codes			
		Released	Recovered	Minutes at large			1	2	3	4
991	850	16:11	16:14	*3*	6	1 A				
992	690	16:17	16:19	*2*	6	1 A				
993	700	16:22	16:25	*3*	6	1 A				
994	760	16:28	16:30	*2*	6	1 A				
995	670	16:32	16:34	*2*	6	1 A				
996	680	16:37	16:42	*5*	6	1 A				
13-Sep-10		**Testlot 7**			**Water temp = 21.0°C**					
				Controls						
970	650	9:21	9:25	*4*	4	1 A				
971	650	9:26	9:31	*5*	5	1 A				
972	660	9:30	9:34	*4*	5	1 A				
973	640	9:35	9:38	*3*	4	1 A				
974	800	9:40	11:05	*85*	6	1 A				