ELECTRIC POWER RESEARCH INSTITUTE

Hydropower Technology Roundup Report

Trash and Debris Management at Hydroelectric Facilities: TR-113584-Vol.10

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PRODUCT DESCRIPTION

This report provides a preliminary examination of the practices and problems associated with trash and debris at hydropower installations. The Hydropower Technology Roundup project surveyed the perspectives of multiple hydropower producers with respect to their management of trash and debris.

Results and Findings

The Trash/Debris Survey identified current practices and technologies, improvements that have been made, significant problems, and opportunities for additional improvements. The report presents background information on trash and debris management, discusses recent trash-related literature, provides results from the Trash/Debris Survey and subsequent follow-up, presents and discusses four case studies showing good practices in trash/debris management. Also, the report provides recommendations for research, demonstration projects, and improvements in the area of trash/debris management.

Challenges and Objectives

This report is aimed to assist hydropower operators to evaluate trash and debris management procedures and to make appropriate equipment investment decisions. Managing trash and debris is a significant issue at many hydroelectric facilities. In some cases, sizable operating expenditures are required for managing trash. Moreover, the failure to effectively manage trash can have serious consequences.

Applications, Values, and Use

There are substantial opportunities for economic gains: Relatively modest improvements in trash and debris management could easily be worth more than $500 million per year in terms of increased electricity generation to hydro utilities in the U.S. and Canada. This Roundup report provides a preliminary basis for enabling individual hydropower producers to consider their own practices and problems, and to determine opportunities for beneficial improvements.

EPRI Perspective

This EPRI Hydropower Technology Roundup report is one of a series that provides information on topics of high-interest to hydroelectric plant operators. The reports are aimed to cover both operation and maintenance issues as well as new and emerging technology and approaches. The first report in the Hydropower Technology Roundup program series was published in 1999. This is the tenth Technology Roundup report.

Approach

Survey forms were sent to investor-owned utilities, cooperatives, state and municipal power agencies, and federal power agencies. After responses were received, additional follow-up discussions were held with selected respondents.

Keywords

Hydropower
Trash Rack
Trash and Debris Management
Plant Efficiency
Head loss

ABSTRACT

This report provides a preliminary examination of the practices and problems associated with trash and debris at hydropower installations. The Hydropower Technology Roundup project surveyed the perspectives of multiple hydropower producers with respect to their management of trash and debris. The Trash/Debris Survey identified current practices and technologies, improvements that have been made, significant problems, and opportunities for additional improvements. The report presents background information on trash and debris management, discusses recent trash-related literature, provides results from the Trash/Debris Survey and subsequent follow-up, presents and discusses four case studies showing good practices in trash/debris management. Also, the report provides recommendations for research, demonstration projects, and improvements in the area of trash/debris management. This provides a preliminary basis for enabling individual hydropower producers to consider their own practices and problems and to determine opportunities for beneficial improvements.

ACKNOWLEDGMENTS

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INTRODUCTION

Background

Managing trash and debris is a significant issue at many hydroelectric facilities. In some cases, sizable operating expenditures are required for managing trash. Moreover, the failure to effectively manage trash can have serious consequences. For example, the interference of trash with water flow through the turbines can result in significant losses of energy generation and, consequently, revenue. Particularly during high flow periods, large burdens of water-borne debris may result in hazards to personnel, equipment, and structures. There are substantial opportunities for economic gains: Relatively modest improvements in trash and debris management could easily be worth more than $500 million per year in terms of increased electricity generation to hydro utilities in the U.S. and Canada.

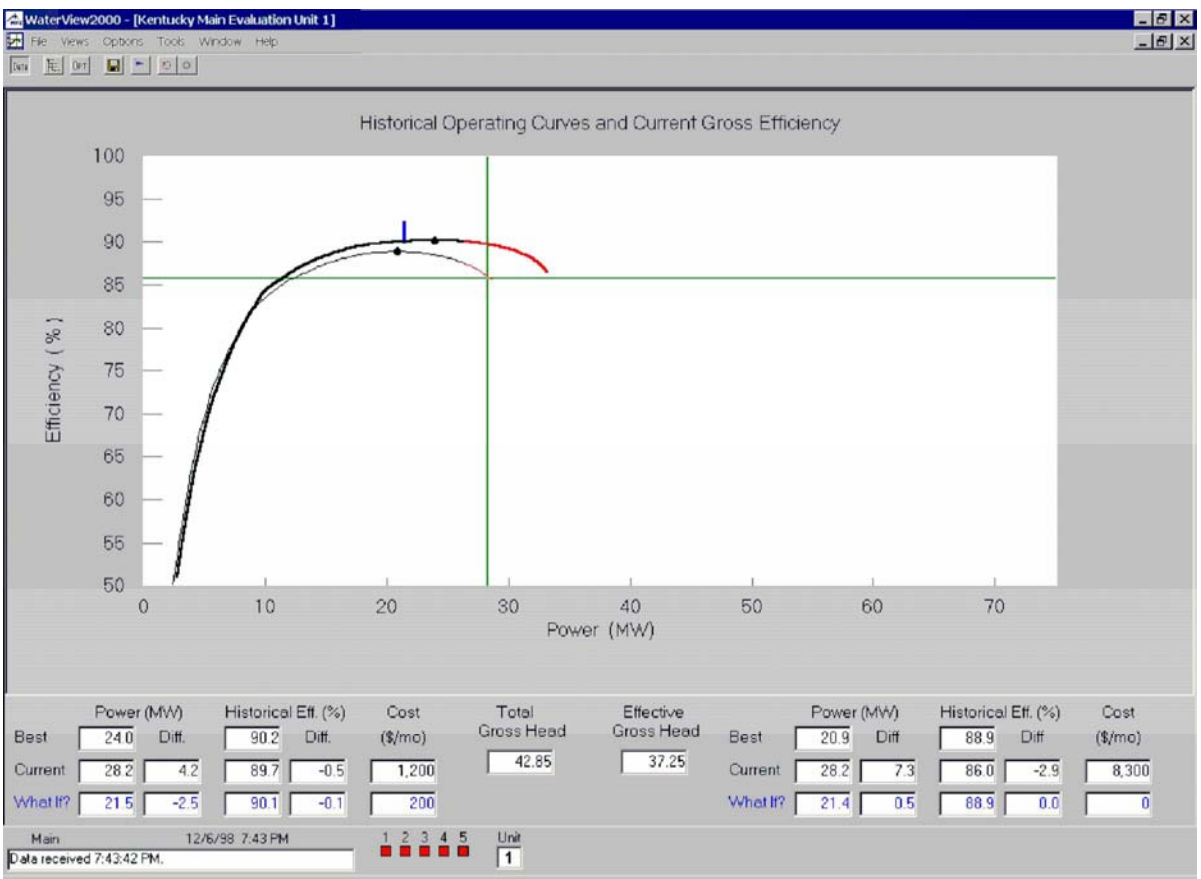

Figure 1-1
Effects of Trash Rack Fouling on Unit Performance

Trash rack fouling dissipates energy and reduces the effective head across hydroelectric generating units, leading to significant losses in efficiency and capacity. Figure 1-1 provides an illustration of these effects [March, Julyv 2000]. This figure displays data from the operation of a plant with a five-foot head loss at the trash racks during a period of high debris loading. The upper curve indicates the expected unit performance at a head of 42.8 feet, without the additional head loss due to trash. The lower curve shows the unit performance at the actual trash-affected head of 37.2 feet. The maximum capacity of the unit has dropped 15% – from 33 MW to 28 MW – and the most efficient load has dropped from 24 MW to 21 MW. At the actual operating point of 28 MW, the unit efficiency has dropped by 4% – from 90% to 86%.

Indirect effects due to the non-uniform distribution of approach velocity created by trash rack fouling produce additional problems. These problems include degradation in hydraulic performance, increased cavitation damage, increased bearing wear, and potential inaccuracies in water flow measurement and related plant operating decisions. Excessive fouling may also contribute to trash rack failure, resulting in repair costs and revenue losses due to unscheduled downtime and replacement power costs.

Survey Approach

During November and December 2006, the project team prepared a survey instrument and surveyed the perspectives of multiple hydropower producers with respect to their management of trash and debris problems at hydropower installations. The Trash/Debris Survey was designed to provide useful information without overly burdening respondents.

Survey forms were sent to investor-owned utilities, cooperatives, state and municipal power agencies, and federal power agencies. After responses were received, additional follow-up discussions were held with selected respondents. A copy of the Trash/Debris Survey is provided in Appendix A.

2 SUMMARY OF RECENT LITERATURE

Historical Perspective

An early hydroelectric handbook, Rushmore and Loff [1923], notes, “Considerable loss of efficiency may result from restricted water passages through racks… (p. 95).” This handbook provides general guidance on trash rack design and approach hydraulics. Another handbook from the same time period provides brief advice on trash rack design and warns that trash rack losses “may be a perceptible portion of the total head when the latter is low [Kent, 1923, p. 2-52].” The widely used *Hydro-Electric Handbook* includes detailed information on approach hydraulics, trash rack design, trash rack head losses, hand-operated trash rakes, mechanical trash rakes, ice-related problems, and trash rack inspection and maintenance [Creager and Justin, 1927].

Related References

A number of comprehensive references produced during the past twenty-five years provide useful information related to trash racks. For example, EPRI [1982] summarizes opportunities for increasing the overall efficiency of hydroelectric power plants, including “better and more frequent cleaning of trash racks (p. S-4).” EPRI [1989] provides an overview of trash rack cleaning technologies and associated costs, information on bar spacing and head losses, and an assessment methodology for evaluating the desirability of trash rack modernization. ASCE [1995] provides detailed guidance for the evaluation and design of hydroplant intakes, including trash racks. Wallerstein [1997] reviews current debris management technologies for hydraulic structures, includes detailed information on trash rack design, trash raking technologies, and spillway design, and provides best practice recommendations. EPRI [1999b], EPRI [2000], and EPRI [2005] discuss the role of trash racks in the overall hydro modernization process, describe new trash rack technologies for reducing head losses and improving fish passage, and provide examples and case studies.

Review of Recent Literature

A review of recent trash-related literature was conducted by searching HCI Publications’ data base of articles (i.e., articles from *Hydro Review* and *HRW*), CD-ROM-based proceedings from major hydropower conferences (HYDRO 2004, 2005, and 2006, the International Association for Hydraulic Research’s IAHR 2000, IAHR-Hydroinformatics 2001, Waterpower, HydroVision), and other references, as available, for the word “trash.” One reference [Jones, 1997] and the corresponding conference presentation [March, 1997] provide a summary of the elements of a trash management strategy. An adapted and updated version of the key elements of trash management strategy is shown in Figure 2-1:

- **Provide routine monitoring and recording of trash rack differentials**
  - **Periodic measurement**
  - **Continuous online monitoring**
- **Investigate hydraulic conditions and upstream sources of trash/debris**
- **Quantify losses, evaluate associated costs, and address operational implications for the plant (and system, if appropriate)**
- **Investigate alternatives**
  - **Manual and automatic trash rack cleaning technologies**
  - **Procedure(s) for trash/debris disposal**
- **Justify, secure funding, and implement appropriate procedures and technologies for trash/debris cleaning and disposal**
- **Define and track trash/debris-related performance metrics**

Figure 2-1
Elements of a Trash Management Strategy

These elements provide a good basis for the following discussion on monitoring, sources and qualifying losses, cleaning alternatives, and performance metrics. The elements also provide a useful structure for reviewing recent literature and the case studies described in Chapter 4. An additional section in this chapter discusses environmental issues related to trash and debris management.

Monitoring

Several of the reviewed articles related to trash racks focus on various methods for monitoring of trash rack head losses. An earlier paper provides an interesting perspective:

> Usually at hydroelectric stations, especially on channel stations, each centimeter of head losses has great significance. According to the data, a decrease of head losses on trash racks of all hydrostations in the USSR by 1 cm can give an additional annual generation of electricity of more than $100 \cdot 10^6$ kWh [Odinets, 1988, p. 497].

Jones [1997] describes a methodology and system for monitoring flow-weighted trash rack differentials. Several papers describe a comprehensive system for monitoring and evaluating environmental and operational data, including trash rack losses, and utilizing the data for plant and system optimization [Adams, 1999; March, 2000; March, 2001; Tuttle, 2003].

Cheng [2003] discusses water level monitoring to determine trash rack fouling in small hydroplants. Craig [2003] and de Montmorency and de Montmorency [2004] describe internet applications, including web-based video cameras, for visual monitoring of trash and ice fouling of trash racks. Keyes and Mitchinson [2003] describe the application of side-scan sonar to the evaluation of trash and debris buildup without interfering with plant operations. March [2004] and Bajic [2004] discuss the effects of trash fouling on signals from acoustic cavitation monitoring systems. Lemon and Lampa [2004] describe the application of an acoustic scintillation flow monitor to evaluate trash rack blockage by comparing measured flow profiles.

Hydraulic Conditions and Upstream Sources

Trash rack fouling depends on a variety of factors, including upstream aquatic and shoreline vegetation, the river elevation and flow, the turbine operating condition, the location of the debris, and the nature of the debris. Typical sources of trash include upstream accumulations on the reservoir bottom; branches, leaves, and debris from the shoreline, washed into the reservoir by swollen creeks and streams; aquatic vegetation; waterlogged trash from floating "trash rafts" which typically include natural debris and man-made materials such as plastic, construction debris, rope, tires, etc. Both strategy and equipment for trash/debris management will vary depending on the composition and origin of the accumulated trash, and the hydraulic conditions carrying trash/debris to the trash racks.

Nielsen [1994] describes B.C. Hydro's integrated debris management strategy. Although the article primarily focuses on the dam safety aspects of debris management, it also discusses a B.C. Hydro review identifying "50 gigawatt-hours per year…that could be gained by optimizing trashrack cleaning methods and frequency (p. 54)." Ranatunga and Roberts [2001] describe a Coanda-effect intake designed to exclude debris and eliminate trash-related maintenance. Armentrout [2002] discusses effective log booms to divert surface debris. Rundqvist [2005] provides a progress report on an extensive research program by CEA Technologies Inc. on dam safety aspects of flood-borne debris. Debris management strategies are discussed, focusing on (1) controlling the upstream yield of debris; (2) intercepting and diverting debris; and (3) reducing dams' sensitivity to debris. The paper also discusses the importance of physical model studies at multiple scales to improve the level of understanding for debris management. Villeneuve [2005] discusses the importance of intake design for proper operation of compact axial turbines and describes the role of free-surface vortices in depositing surface debris onto trash racks. Sharma [2006] describes experiences in India with seasonally blocking lower trash racks to reduce silt entrainment. Andaroodi [2005] provides a standardized intake and trash rack design for application in small hydro plants, and Moutafis [2006] describes a moderately successful intake designed to divert and remove sediment and debris upstream from the trash rack for a small hydro plant.

Quantifying Losses

Tuttle [2003] describes the implementation of a trash rack monitoring system and discusses the application of the trash rack monitor to (1) evaluate the head losses across the trash racks for comparison with safety design limit of the racks; (2) evaluate the economic impact of energy and capacity losses resulting from trash rack fouling; and (3) provide operational optimization of the plant during conditions when the effective head is reduced due to trash rack fouling. Leiler [2004] reports, "As our experiences and data on existing installations show the loss of power generation, caused by head loss on the trash rack, is often underestimated. Power production increases after installing a custom engineered trash rack cleaning solution are annually between 5% and 25%." March and Wolff [2004] describe data analyses for four units at one plant showing that the lost revenue produced by trash rack fouling was $2,000,000 for a two year analysis period.

Cleaning Alternatives

Schneeberger [1994] provides a description of automated equipment for trash rack cleaning and debris removal at several hydro projects. Tarbell [1995] describes the application of surface heaters to the elimination of frazil ice build-up on trash racks. Munn [1996] details the operation of an automatic machine for removing large quantities of weeds from trash racks. Rajpal and Lumar [2002] discuss the design and installation of fully automatic machinery for cleaning the trash racks of small hydro units in India. Dubé [2004] describes the installation and successful operation of a large trash raking system, including significant reductions in trash-related maintenance costs and production losses. Leiler [2004] describes one company's experience with a wide range of applications for trash rack cleaning, debris handling, and sedimentation control. Harreiter [2005] describes and illustrates two trash raking designs utilized in Austrian small hydro plants. Hammelmueller [2005] and Kienberger et al. [2006] describe trash rack cleaning systems for HYDROMATRIX® plants in Sudan and Austria. Bryan [2006] describes successful experience with using a hydraulically operated grapple to remove debris at turbine intakes.

Performance Metrics

Wolff and March [2002], Wolff [2002], and Wolff [2003] discuss the application of automated data analyses to compute the lost production opportunity due to trash rack fouling and the current market value of this lost production opportunity and recommend the development of a performance metric based on trash rack losses. March and Wolff [2004] describe a performance metric, "Avoidable Loss Efficiency," which can provide a quantitative measure for the effectiveness of trash rack cleaning procedures. The authors report, "The avoidable loss efficiency quantifies energy losses that can be minimized with appropriate maintenance activities. Trash rack fouling is the most common avoidable loss occurring in hydroplants. Penstock fouling caused by biological growth and losses due to penstock or tunnel degradation can also be addressed with this indicator [March and Wolff, 2004]." March [2005] describes best practices for hydro performance, including quantitative performance metrics for avoidable energy losses such as trash rack fouling.

Environmental Issues

Under "classical" trash rack design (see Creager and Justin [1927]), a bar spacing that corresponds to minimum turbine passage dimensions is recommended, with a maximum spacing of 5-inch to 6-inch and a minimum of 1.25-inch to 2.5-inch depending on unit type, local conditions, and type of debris. At many hydropower projects, trash and debris problems are increasing as the bar spacings decrease due to modern environmental regulations and relicensing agreements related to fish passage. Several EPRI reports, including EPRI [1994], EPRI [1996], EPRI [1999a], EPRI [2001], and EPRI [2006], provide useful information on screening systems for guiding fish and reducing fish impingement and entrainment. Nestler [1998] describes a "veneer" of wedge-wire screens fastened to the existing trash racks of a pumped-storage plant to prevent fish passage. Culligan [1998] discusses the importance of the accelerated collaborative relicensing process in enabling a cost-effective trash rack overlay rather than a complete trash rack replacement with angled bars and narrow spacing. Inci [2004] provides data on increased head losses and decreased power due to zebra mussel infestation, with the largest losses occurring at the trash racks. The International Energy Agency reference, IEA [2006], discusses the importance of more frequent trash rack cleaning in reducing fish impingement on Eicher fish screens. Young and Wicke [2005] describe the capture, storage, and relocation of woody debris to provide improved fish habitat downstream from a hydro plant.

3
SURVEY RESULTS

Summary of Results

Trash and debris surveys were sent to sixteen utilities. Eleven utilities completed the Trash/Debris Survey forms, one utility declined to participate, and two utilities were not about to respond in time to be included. Completed surveys were received from seven investor-owned utilities, two state or municipal power agencies, one federal power agency, and one cooperative utility. The survey results are summarized in Table 3-1. To provide for convenient reference, the survey questions are given below:

1. Are you entirely satisfied with your trash/debris practices, or do you think you may have significant opportunities for improvement?

2. Do you have any significant trash-related problems and, if so, briefly describe.

3. Have you made any major changes to your methods of trash management over the past ten years? If so, briefly describe.

4. Do you know to what extent your facilities are experiencing energy production losses or other economic losses as a result of trash accumulations?

5. Do you use automatic trash raking equipment? If so, who is the manufacturer(s)?

6. Do you keep data on amounts of trash – for example, tons removed annually (or other data)?

7. Does your organization budget or identify funds specifically for trash management?

8. Does trash arrive at your facility(ies) continually (year round), or seasonally?

9. Would you be interested in participating in a future trash/debris management workshop or symposium?

Results by question from the Trash/Debris Survey are provided in Appendix B. Complete survey responses are provided in Appendix C. In Appendices B and C, the noted "Supplementary information" was obtained during follow-up discussions with respondents.

Table 3-1
Summary of Trash/Debris Survey Results

Utility #	Type of Organization	Q 1. Room for improvement?	Q2. Trash-Related Problems?	Q3. Recent Changes?	Q4. Production Losses?	Q5. Trash Raking Equipment?	Q6. Trash Data?	Q7. Budget for Trash?	Q8. Seasonal Trash?	Q9. Workshop Interest?
1	Investor-Owned Utility	Always improvement opportunities	Site-specific problems, including leaves generally and milfoil at one plant; Increasing problems due to relicensing requirements for fish passage (one inch bar spacing)	Occasionally, trash rack cleaning machines will be justified and installed	Trash rack differentials are monitored on many plants and used to prioritize maintenance activities	Various trash cleaning machines have been installed, including Cross Machine, Ashland, Alpine Machine	No data	No separate budget; New equipment would be a separate capital budget	Seasonal increase during high flows in spring and fall	Possibly
2	State/Municipal Power Agency	Not satisfied with trash practices	Algae passes through water distribution intake	No	No production losses are associated with the problem	None	No data	No separate budget	Primarily a problem during summer	Yes
3	Cooperative	Reasonably pleased, but always room for improvement	Significant site-specific problems have been resolved	Justified and installed trash rack cleaning machine at largest plant	Trash rack loss data was used to justify trash rack cleaning machine at largest plant	Kuenz H-4000 trash cleaning machine at one plant	Historical data on trash rack differentials	No separate budget	Continual trash problems; seasonal increase during high flows	Possibly
4	Investor-Owned Utility	Significant opportunities for improvement	Significant trash rack fouling problems at multiple plants; Safety concerns with trash raking activity	Justified and installed trash rack cleaning machines at larger plants	Production increases ranging from 7% to 12% identified at sites with trash rack cleaning machines	Kuenz machines and North Fork Electric Dragrakes have been installed	Limited data is available on surface debris removal at pumped-storage project	Labor dollars for overtime included in budget	Continual trash problems, peaking in fall due to leaves	Yes
5	Investor-Owned Utility	Generally satisfied	Site-specific problems	Replacing trash raking machinery with larger machinery	Power production losses or trash rack differentials are monitored and used to prioritize maintenance activities	Cross Machine trash rakes were traditionally used, but now Atlas Polar is the preferred supplier	No data	No separate budget	Seasonal increase in the fall due to leaves	May be interested in general discussion
6	Investor-Owned Utility	Could be improved	Significant problems with surface debris	Installed trash rack monitoring system	Trash rack monitoring system provides economic costs associated with trash losses	No, did at one time	Extensive data on trash-related losses; limited data on debris removal	Specific trash-related budget	Continual trash problems; seasonal increase during high flows in spring and fall	Yes
7	Investor-Owned Utility	Presently satisfied	Infrequent accumulations of surface debris at one project	Increased sorting of man-made debris for landfill disposal	Not aware of any losses	Manually operated rakes at several projects	General idea of volumes, but no specific records	No separate budget	Seasonal trash events during high flows	Probably not at this time
8	Investor-Owned Utility	Improvements needed	Significant problems during high flow events	Added new rakes at two plants, log booms at three plants, and one sluice gate	May lose 1 to 2 MW from vertical units and completely shut down small horizontal units	One installation with North Fork Electric Dragrake	No data	Some labor allocated for trash removal	Seasonal trash events	Yes
9	Investor-Owned Utility	Improvements (automated trash rakes) needed	Several plants have significant problems due to weeds and leaves	Gates modified to permit sluicing; Units are successively motored to move trash; Compressed air is used to move mats of weeds	Three plants exhibit a generation decrease as weeds and leaves accumulate	None	No data	No separate budget	Continual trash problems due to logs, trees, woody debris; large seasonal increase during high flows in spring; large seasonal increase from weeds and leaves in late summer and fall	No
10	State/Municipal Power Agency	Limited opportunity due to ongoing projects	Significant trash rack fouling problems at two plants	Installed trash rack monitoring systems; increased cleaning frequency; redesigned trash rack to reduce losses; justified and ordered trash rack cleaning machine	Recoverable losses of $500,000/year at one plant, $250,000/year at another	Use clam shell and divers at two plants; Ordered Muhr-Brannenburg trash rack cleaning machine for one plant	Extensive data on trash-related losses; limited data on debris removal	No separate budget	Seasonal trash events during high flows	Yes
11	Federal Power Agency	Significant opportunities for improvement	Site-specific problems, including aquatic grass, milfoil, trees, brush	Installed trash rack monitoring systems; justified and installed trash rack cleaning machines; increased attention to trash problems	Trash rack monitoring system provides economic costs associated with trash losses	Bieri Hydraulik trash cleaning machine at one plant; two Atlas Polar units at another plant	Extensive data on trash-related losses; limited data on debris removal due to dredging	Specific trash-related budget for the past two years	Site-specific; continual build-up at main river plants; seasonal milfoil and aquatic grass problems at some plants	Yes. Very interested.

4
CASE STUDIES

Overview

The four Case Studies in this chapter describe examples where utilities have assessed their organization's trash/debris management practices and made constructive, cost-effective improvements. The Case Studies follow the elements of a trash management strategy shown previously in Figure 2-1.

Case Study – Utility # 3

Description of Utility

The utility is a cooperative power producer with three hydro plants.

Monitoring

Differential pressures across the trash racks are monitored and recorded. The data is used to schedule operation of a trash rack cleaning machine at one plant and to schedule manual cleaning at the other two plants.

Hydraulic Conditions and Upstream Sources

In addition to its primary role in cleaning the trash racks, the Kuenz machine helps to stir up deposited sand. This allows the sand to be flushed through the plant and alleviates a sedimentation problem at the plant.

Quantifying Losses

Historical trash rack loss data was used for quantifying economic losses, estimating benefits, and justifying capital expenses for the trash rack cleaning machine.

Cleaning Alternatives

A Kuenz H-4000 hydraulic trash rack cleaning machine is used at the largest plant. Portable cranes and clam shells are used at the other two plants.

Performance Metrics

Nothing is formally implemented, but an analysis of pre-installation and post-installation trash rack loss data is underway to quantify the benefits from the recently installed trash rack cleaning machine.

Case Study – Utility # 4

Description of Utility

The utility is an investor-owned utility with multiple hydroplants, including pumped-storage.

Monitoring

Differential pressures across the trash racks are monitored and recorded at many plants. The data is used to schedule operation of trash rack cleaning machines and/or to schedule manual cleaning.

Hydraulic Conditions and Upstream Sources

Nothing on hydraulic conditions and upstream sources of trash and debris was reported in the Trash/Debris Survey.

Quantifying Losses

Historical trash rack loss data and estimated benefits were used for quantifying benefits and justifying capital expenses for installation of trash rack cleaning machines where justified.

Cleaning Alternatives

Kuenz hydraulic trash rack cleaning machines and North Fork Electric Dragrakes are used, as well as portable cranes and clam shells.

Performance Metrics

Production data is tracked, enabling data analyses to quantify the benefits from improved maintenance practices and improved cleaning technologies. Production increases, ranging from 7% to 12%, have been identified at sites with improved trash rack cleaning machines.

Case Study – Utility # 10

Description of Utility

The utility is a state/municipal power producer with three hydroplants.

Monitoring

At two plants, differential pressures across the trash racks are monitored and recorded using commercial trash rack monitoring systems (WaterView Trash Rack Modules).

Hydraulic Conditions and Upstream Sources

A trash barrier, designed using hydraulic model tests, has been installed upstream from the larger project to divert oncoming debris to the shore where it can be handled using a clam bucket.

Quantifying Losses

Data from the trash rack monitoring systems is used (1) to evaluate the head losses across the trash racks for comparison with safety design limit of the racks; (2) to evaluate the economic consequences of energy and capacity losses resulting from trash rack fouling; and (3) to provide operational optimization of the plant during conditions when the effective head has been reduced due to trash rack fouling. Analyses of data from the trash rack monitoring systems have been used to compute recoverable losses (approximately $500,000/year at the smaller plant and $250,000/year at the larger plant) and justify the capital expenses associated with new, lower loss trash racks and improved trash rack cleaning machinery at the smaller plant.

Cleaning Alternatives

Cranes and clam shells are used at both plants. A Muhr-Brannenburg trash rack cleaning machine is currently being manufactured for the smaller plant. Since installation of the trash rack monitoring systems, the frequency of cleaning has increased significantly at both plants. Custom-built automatic traveling screens and trash rakes are used on adult and juvenile fish bypass systems.

Performance Metrics

No formal performance metrics are currently implemented for trash and debris management. However, an analysis of pre-installation and post-installation trash rack loss data will be conducted to quantify and confirm benefits from the new, lower loss trash racks and the improved cleaning machinery.

Case Study – Utility # 11

Description of Utility

The utility is a federal power producer with multiple hydroplants, including pumped-storage.

Monitoring

At sixteen plants with trash/debris problems, differential pressures across the trash racks are monitored and recorded using commercial trash rack monitoring systems (WaterView Trash Rack Modules).

Hydraulic Conditions and Upstream Sources

Some identification of upstream sources for trash/debris has been conducted. Many plants have provisions for diverting and sluicing upstream debris.

Quantifying Losses

Data from the trash rack monitoring systems is used (1) to evaluate the head losses across the trash racks for comparison with safety design limit of the racks; (2) to evaluate the economic impact of energy and capacity losses resulting from trash rack fouling; and (3) to provide operational optimization of the plant during conditions when the effective head has been reduced due to trash rack fouling. Analyses of data from the trash rack monitoring systems have been used to prioritize and guide mitigation activities (e.g., "burping" units, cleaning racks) and to justify the capital expenses associated with improved trash rack cleaning machinery.

Cleaning Alternatives

Cranes, clam shells, and divers are used at many plants. A Bieri Hydraulik trash rack cleaning machine is installed at one plant, and two Atlas Polar trash rack cleaning machines are installed at another plant.

Performance Metrics

Although no formal performance metrics are currently implemented for trash and debris management, budget is explicitly provided for trash management. The data from the trash rack monitoring systems has been important in focusing attention on trash-related problems.

5
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This report provides a preliminary examination of the practices and problems associated with trash and debris at hydropower installations. The project surveyed the perspectives of multiple hydropower producers with respect to their management of trash and debris problems. The Trash and Debris Survey included current practices and technologies, improvements that have been made, significant problems, and opportunities for additional improvements. The report presents background information on trash and debris management, discusses recent trash-related literature, provides results from the Trash/Debris Survey and subsequent follow-up, presents and discusses four case studies showing good practices in trash/debris management, and provides recommendations for improvements in the area of trash/debris management.

Conclusions

Based on the results of the Trash/Debris Survey and subsequent follow-up with respondents, it appears that improvements in trash management practices will offer worthwhile opportunities for improved performance at many hydroelectric projects. Some hydro project managers have recently undertaken trash management improvement programs with quite meaningful results. Yet, at many projects, the steps have not been taken to ascertain whether or not improvement opportunities exist. However, a sampling of information from projects strongly suggests that there are, in fact, numerous opportunities that, if appropriately acted upon, could yield significant economic and energy production benefits.

Recommendations

This Technology Roundup report relies to a large extent on information gained from 11 survey respondents. Additional information is prospectively available that could be helpful in examining trash/debris management issues. In particular, it is recommended that:

- Effort should be put into acquiring studies and reports that have been not publicly disseminated;
- Information on trash and debris management in potentially applicable but unrelated areas, such as bridge structures, should be reviewed for relevance to hydroelectric facilities;
- A survey of trash rake manufacturers should be conducted to gain some of their experience and perspectives with regard to trash/debris management.

In addition, to aid hydro power producers in their efforts to evaluate and improve trash/debris management practices, it is recommended that the following should be developed:

- A spreadsheet-based method for assessing opportunities to reduce hydraulic losses via trash management improvements;
- A "Best Practices" document to provide guidance for making beneficial improvements in trash/debris management.

Further, to aid in disseminating information for improving trash management practices, it is recommended that:

- Plans should be developed for a series of trash/debris management workshops. (These workshops would also provide opportunities to gain additional information from participants on current trash management practices.)

Finally, as identified in the literature review, there appear to be promising opportunities for improving the technology for monitoring losses (i.e., hydraulic differentials) across trash racks. However, several of these technologies have not reached commercialization. It is recommended that:

- Additional investigation should be made of advanced technologies that have prospective application for trash rack monitoring. In particular, it is recommended that acoustic/cavitation and acoustic/scintillation technologies should be investigated for application to trash and debris monitoring and, also, that these measurement methods should be compared to methods currently available and in use.

6
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A

SURVEY INSTRUMENT

Trash/Debris Survey

We hope you can help by responding to the questions in this brief survey about trash/debris management practices. We're soliciting responses from a selected few utilities. Your responses will help guide our investigation of trash/debris-related practices and problems.

- We've tried to make it easy to respond to this survey. We need your help, and we don't want to waste your time.
- Your responses will be kept strictly confidential, except that compiled results will be shared on an anonymous basis with other survey respondents.

We sincerely appreciate your help.

If you have questions, please send an e-mail to me, Carl Vansant, at cvansant@hcipub.com, or call me at 816-931-1311 ext. 115.

Questions

After each of the questions below, please type your response into this MS Word document. Then, save the document with your initials appended (e.g., "Trash Survey_XYZ.doc") and e-mail the document with your responses to Carl Vansant (cvansant@hcipub.com).

0. Example – Note, when you type in your answers, they will appear in red.
This is an example.

1. Are you entirely satisfied with your trash/debris practices, or do you think you may have significant opportunities for improvement?

2. Do you have any significant trash-related problems and, if so, briefly describe.

3. Have you made any major changes to your methods of trash management over the past ten years? If so, briefly describe.

4. Do you know to what extent your facilities are experiencing energy production losses or other economic losses as a result of trash accumulations?
5. Do you use automatic trash raking equipment? If so, who is the manufacturer(s)?

6. Do you keep data on amounts of trash – for example, tons removed annually (or other data)?

7. Does your organization budget or identify funds specifically for trash management?

8. Does trash arrive at your facility(ies) continually (year round), or seasonally?

9. Would you be interested in participating in a future trash/debris management workshop or symposium?

Who filled out this survey?

- Name:
- Telephone:
- E-mail:

B

SUMMARY OF SURVEY RESULTS BY QUESTION

Question 1. Are you entirely satisfied with your trash/debris practices, or do you think you may have significant opportunities for improvement?

Table B-1
Responses to Survey Question #1

Respondent for Utility #:	Comments:
1	There are always improvement opportunities. We occasionally add trash raking machines where warranted and/or where other related projects may be going on. (Supplemental information: The process used for quantifying benefits and justifying capital expenditures is left up to the individual Areas.)
2	We are not satisfied with our trash practices.
3	We are reasonably pleased with what we do but there is always room for improvement.
4	I believe we still have significant opportunities for improvement.
5	Currently, we have a variety of practices depending on the facility. At two of our facilities, we have not trash rack cleaning systems nor is it presently required. Still, we do monitor the debris that does come down to keep track if we need to add trash cleaning equipment at these facilities. At some of our facilities, we are able to collect the trash that comes onto the dam, and then pass it downstream through a trash gate system. At some of our facilities, we collect the trash and haul it off. Currently we utilize normal municipal or county removal agencies for this work and pay them to haul the debris to a landfill. At this time, these practices are not very onerous or expensive. We are not required to implement special handling of the trash and are able to utilize conventional means for disposal where we need to. We probably are in a case where we don't have significant opportunity for improvement on our existing system.
6	They could be improved.
7	We are presently satisfied with our trash/debris practices and do not have a need for improvement.
8	We have made many improvements with logbooms, sluice gates, rakes, etc. We still have improvements needed at the stations where trash has the most impact.
9	Automated trash rakes at several locations would reduce physical manpower requirements.
10	We have limited future opportunities for significant benefits since we have made a number of improvements since 2000. I will be referring to our two largest projects (18 units, 600 MW; 11 units, 1300 MW).
11	I think there may be significant opportunities for improvement.

Question 2. Do you have any significant trash-related problems and, if so, briefly describe.

Table 6-1
Responses to Survey Question #2

Respondent for Utility #:	Comments:
1	Typically the biggest generic issues are with leaves in the Fall. On one river there are some milfoil issues for a couple of weeks in the Fall as well. As we have recently migrated to racks with one –inch clear spacing as a result of our re-licensing, there are increasing complaints about keeping racks clean. Hence the occasional additions of new raking machines mentioned in No. 1 above.
2	We are a raw water provider for a major metropolitan area. We have an algae problem in the summer. The algae breaks loose from the bottom of our regulating reservoirs and it is carried through the water supply system. The algae clogs downstream user's meters and increases the amount of byproduct after chlorine is added to the water.
3	Not any longer. We did have significant sand deposition at our largest plant prior to the installation of a trash rack cleaning machine. (Supplemental information: In addition to its primary role in cleaning the trash racks, the Kuenz H-4000 machine helps to stir up the deposited sand and allow the sand to be flushed through the plant.)
4	We still have manual "war wagon" style trashrakes at our smaller projects. These style rakes only rake four-feet of trashrack per cycle. By the time a mechanic uses the rake on the entire intake structure (140-feet in length) two hours have elapsed and the area where he started is again clogged with trash. We had an anonymous survey of our mechanics and one question was "what is the most dangerous task that you do?" The answer was "rake trash" in over 85% of the responses.
5	No. The primary issue we had was the equipment we had used. We have been replacing our trash raking equipment with larger machinery and this has addressed most of the issues we had.
6	Being the last dam on a major river, we have a significant amount of floating debris that collects on the surface on the north side of the dam. It can literally cover acres of area and leads to problems with trash clogging our intakes for our units.
7	During high flow or flood events (every 5-10 years), on one project, we can get large volumes of woody debris in our reservoir. We have two log booms to stop that debris from getting to the dam and turbine inlets. Using portable booms, we move the debris to a takeout point for sorting and processing with larger marketable timber sold, smaller debris offered to the public for firewood, and smaller debris burned.
8	Our problems are mostly on the long run of rivers that have the least development during high water events.
9	Several Mississippi River watershed hydroplants have significant weed and leaf periods in late summer and fall requiring rack raking several times each day.
10	We currently estimate we are loosing about $1,000,000 per year at the smaller project and $1,500,000 per year at the larger project. Of those losses, we have determined we can feasibly recover about $500,000 per year at the smaller project and $250,000 per year at the larger project. (Supplemental information: A trash barrier, designed using hydraulic model tests, has been installed upstream from the larger project to divert oncoming debris to the shore where it can be handled using a clam bucket.)
11	Aquatic grass is major problem at one dam. The grass blankets the trash racks. The grass must be removed by manual labor. Trees and brush are a problem at one main river dam. Trees, brush and milfoil are major problems at another main river dam. Tree loss from the pine beetle is a major source of trash. The logistics of disposal is a major problem. Trash must be placed in certain landfills. Disposal costs are increasing.

Question 3. Have you made any major changes to your methods of trash management over the past ten years? If so, briefly describe.

Table 6-2
Responses to Survey Question #3

Respondent for Utility #:	Comments:
1	No, other than what is mentioned above.
2	No, we currently collect floating algae from a row boat or at the intake gates with racks.
3	Yes. In 2003 we installed a hydraulic trash rack cleaning machine on our largest plant. (Supplemental information: Historical trash rack loss data and estimated benefits were used for quantifying benefits and justifying capital expenses for the trash rack cleaning machine.)
4	Yes. Our larger projects now have automated trash rakes. Either the Dragrake style by North Fork Electric, or the gigantic “war wagon” style by Kunz.
5	As mentioned above, we have installed “automatic” trash raking systems or manually operated hydraulic trash rake equipment at our stations. This has significantly decreased the amount of time and labor required for this activity. While we do have several systems that are automatic, we currently do not run them remotely. We continue to have a person on-site while the trash handling process is ongoing.
6	No major changes.
7	Other than more attention given to sorting out man-made debris for landfill disposal, no major changes.
8	We have added new rakes at two stations, heavy log-booms at three stations, and one sluice gate. We also have equipment to remove sub-surface build up.
9	Spillway gates adjacent to the powerhouse were modified at 2 plants in order to be able to flush the weeds & leaves without removing them from the river. For one station, an inflatable dam replaced a section of flashboards. For the other, a set of wooden stop logs was replaced with a two-section motor operated slide gate. For trash sluicing, the upper section is raised to pass the weeds & leaves. When the gate is needed to pass higher river flows, the upper section is bolted to the lower section and the entire gate is raised. Generating units are motored, allowing debris to float as flow is shut off through the units successively, moving the debris to the nearest spillway gate. Compressed air is bubbled through wands stuck through mats of weeds to help float them away. The latest license we have been issued has an Article requiring the passing of large woody debris through a reservoirs spillway gates for habitat in the downstream rapids. Licenses obtained earlier only required the removal of un-natural material.
10	We have installed trash rack loss monitoring equipment (2001) at both hydro projects and started a trash rack replacement project at the smaller project. At both projects, we clean much more frequently, based on the differentials, using a clam bucket and divers. The new trash racks have a wider bar spacing and improved hydraulic profile (lower clean rack losses). Also at the smaller project, we have executed a contract to install a new trash rake/cleaner in 2008 (manufactured by Muhr – Brannenburg, Germany).
11	Yes, during the last few years, more attention was paid to trash buildup. Three years ago, approximately 4,000 cubic yards of trash was removed at one facility. Last year money was budgeted to remove debris at our facilities. Currently, the inspection program tracks the debris buildup and prioritizes the removal activities. Trash rack differential pressure monitoring is installed at most plants. This data is used to detect buildup. Most of our trash racks were designed for a maximum of 5 feet of differential pressure. The monitoring system alarms so that action may be taken to prevent trash rack failure. (Supplemental information: The removal of upstream debris at one plant had a significant impact on subsequent index test results.)

Question 4. Do you know to what extent your facilities are experiencing energy production losses or other economic losses as a result of trash accumulations?

Table 6-3
Responses to Survey Question #4

Respondent for Utility #:	Comments:
1	Yes. We have rack differential alarms installed on many facilities. (Supplemental information: Typically, the rack differentials guide roving maintenance crews in determining priorities for manual rack cleaning or operation of trash raking machines.)
2	Very Minimal. Most of our reservoir intakes are very deep and the trash does not get to the racks.
3	We do not track lost production due to trash rack losses. (Supplemental information: An analysis of pre-installation and post-installation trash rack loss data is underway to quantify the benefits from the trash rack cleaning machine.)
4	Yes. We have data indicating that some of our sites with automatic trashrakes is now producing 12% more mwhs than before. Our worse performers are in the 7% range on a plant that historically produced 110,000 mwhs annually.
5	We currently monitor trash build up by observing loss of generation or intake trash rack differentials. (Water level upstream of trash rack compared to the water level immediately downstream of the trash rack.) During the fall, when we have heavy debris loads, we will often remove trash based on efforts to maintain generating outputs at their peak. We keep track of this at our small plants. When we see this we will rake. We have differential monitoring.
6	Yes, at times our differential pressure will climb indicated that we are not getting appropriate flow through our trash racks.
7	We are not aware of any energy or generator related losses due to debris on our trash racks.
8	We may loose 1 or 2 MW off the verticals or completely shutdown the small horizontals.
9	The losses would be very difficult to quantify. Three plants that see the large quantities of leaves & weeds will show a gradual decrease in generation and an increase in trash rack differential. Maintenance is then called out, the units are motored for 15 minutes while the racks are raked, and the cycle starts again.
10	Yes – see above.
11	Yes. We use in-house developed software (WaterView) to track the trash rack head loss and assign a dollar value to the loss.

Question 5. Do you use automatic trash raking equipment? If so, who is the manufacturer(s)?

Table 6-4
Responses to Survey Question #5

Respondent for Utility #:	Comments:
1	Yes. Cross Machine, Ashland, Alpine Machine.
2	No mechanical cleaning equipment.
3	We have a Kuenz H-4000 hydraulic trash rack cleaning machine at one of our three plants and use portable cranes and clam shells at the other two.
4	Dragrake style by North Fork Electric or the gigantic "war wagon" style by Kunz.
5	Yes, we have used Cross Machine trash rakes but have more recently adopted Atlas Polar equipment as our preferred supplier.
6	No, we did at one time.
7	We have manually operated trash rakes on several sites.
8	We have one new installation built by North Fork Electric.
9	No.
10	Also at the smaller project, we have executed a contract to install a new trash rake/cleaner in 2008 (manufactured by Muhr – Brannenburg, Germany). We have automated traveling screens and trash rakes on our adult and juvenile fish bypass systems, but none on the generating unit intakes (yet – see above). Manufactures of the bypass trash rakes included Atlas Polar and Kenix both of which have been replaced by a custom built unit.
11	Yes. One plant uses Bieri Hydraulik (www.bierihydraulik.com). The machine has automatic capability but is always operated in manual for safety reasons; Another plant uses Atlas Polar (two machines: one at the diversion dam and one at the fore bay);

Question 6. Do you keep data on amounts of trash – for example, tons removed annually (or other data)?

Table 6-5
Responses to Survey Question #6

Respondent for Utility #:	Comments:
1	Not that I am aware of.
2	No, but we manually remove several tons of wet algae from our tunnel gates/reservoir facility every year.
3	No (Supplemental information: Differential pressures across the trash racks are monitored and recorded. The data is used to schedule operation of the trash rack cleaning machine at one plant and to schedule manual cleaning at the other two plants.)
4	No. We do maintain information on how much debris we remove from the lake of our pumped storage project using a "trash skimmer".
5	No.
6	Yes, we keep this information.
7	We have a general idea on trash volumes by year but no specific records.
8	No.
9	No.
10	No. Just labor and equipment costs annually.
11	Yes, when the trash is removed by dredging. The volume of trash removed by the maintenance staff at each plant is not tracked.

Question 7. Does your organization budget or identify funds specifically for trash management?

Table 6-6
Responses to Survey Question #7

Respondent for Utility #:	Comments:
1	I believe this activity is included in the general O&M budget. New machines would be a separate capital budget.
2	No, but we should.
3	No.
4	Yes. Labor dollars for overtime.
5	Currently, these costs are imbedded in our annual operating budgets are not specifically accounted for.
6	Yes.
7	Trash removal is incorporated into our normal O&M budget. For extraordinary years, we will seek additional, special funding.
8	We have in house labor budgeted with a portion of their time allocated to remove trash.
9	Ordinary trash removal is considered as part of normal operation & maintenance expense for each station. Work orders are established to track costs associated with one-time projects such as dredging to remove sunken woody debris in front of a powerhouse or disposal of multiple years of accumulated debris from a station.
10	No.
11	Yes, for the last two years. Previously, trash removal projects were 'stand-a-lone' projects submitted each budget cycle. (Supplemental information: The data from the trash rack monitoring systems has been important in focusing attention on trash-related problems.)

Question 8. Does trash arrive at your facility(ies) continually (year round), or seasonally?

Table 6-7
Responses to Survey Question #8

Respondent for Utility #:	Comments:
1	Generally seasonally, with spring and fall being the higher load times.
2	Mostly seasonally. This is due to the algae blooms in the summer as a result of more sunlight and higher water temperatures.
3	Year round but the problem is much worse during high flow periods and during the fall/winter die-off period.
4	Year round with the peak period being the fall because of leaves.
5	We experience a much heavier trash load in the fall when the leaves come down. During this period of time we will need to rake trash several times each day. Outside of that, raking frequency depends largely on rack differential warning or operator experience.
6	Continually, although the rainy seasons in the spring and fall are the worst.
7	Usually trash arrives seasonally during periods of higher flows bringing down floating debris that would otherwise be above the normal water level.
8	Seasonally.
9	Logs, trees, & woody debris in small quantities throughout the ice-free season, large quantities in the spring runoff, leaves & weeds in late summer & fall.
10	Large/noticeable amounts are seasonally or large runoff event related.
11	Both. Trash builds up at most main river plants continually. The buildup is most severe after heavy flows. Milfoil and aquatic grass are seasonal problems experienced at several projects.

Question 9. Would you be interested in participating in a future trash/debris management workshop or symposium?

Table 6-8
Responses to Survey Question #9

Respondent for Utility #:	Comments:
1	Possibly. (I would certainly appreciate the opportunity for some one from our O&M staff to participate, if possible.) (Supplemental information: Defining and tracking performance metrics for trash/debris management is a workshop topic of potential interest.)
2	Yes.
3	Possibly.
4	Yes.
5	We may be interested in this if something is put together that would involve general discussions and issues.
6	Yes.
7	Probably not at this point in time.
8	Yes.
9	No.
10	Yes
11	Yes. Very interested.

C
COMPLETE SURVEY RESULTS BY UTILITY

Utility # 1

1. Are you entirely satisfied with your trash/debris practices, or do you think you may have significant opportunities for improvement? There are always improvement opportunities. We occasionally add trash raking machines where warranted and/or where other related projects may be going on. (Supplemental information: The process used for quantifying benefits and justifying capital expenditures is left up to the individual Areas.)

2. Do you have any significant trash-related problems and, if so, briefly describe. Typically the biggest generic issues are with leaves in the Fall. On one river there are some milfoil issues for a couple of weeks in the Fall as well. As we have recently migrated to racks with one –inch clear spacing as a result of our re-licensing, there are increasing complaints about keeping racks clean. Hence the occasional additions of new raking machines mentioned in No. 1 above.

3. Have you made any major changes to your methods of trash management over the past ten years? If so, briefly describe. No, other than what is mentioned above.

4. Do you know to what extent your facilities are experiencing energy production losses or other economic losses as a result of trash accumulations? Yes. We have rack differential alarms installed on many facilities. (Supplemental information: Typically, the rack differentials guide roving maintenance crews in determining priorities for manual rack cleaning or operation of trash raking machines.)

5. Do you use automatic trash raking equipment? Yes. If so, who is the manufacturer(s)?Cross Machine, Ashland, Alpine Machine

6. Do you keep data on amounts of trash – for example, tons removed annually (or other data)?Not that I am aware of.

7. Does your organization budget or identify funds specifically for trash management? I believe this activity is included in the general O&M budget. New machines would be a separate capital budget.

8. Does trash arrive at your facility(ies) continually (year round), or seasonally? Generally seasonally, with spring and fall being the higher load times.

9. Would you be interested in participating in a future trash/debris management workshop or symposium? Possibly. (I would certainly appreciate the opportunity for some one from our O&M staff to participate, if possible.) (Supplemental information: Defining and tracking performance metrics for trash/debris management is a workshop topic of potential interest.)

Utility # 2

1. Are you entirely satisfied with your trash/debris practices, or do you think you may have significant opportunities for improvement? We are not satisfied with our trash practices.

2. Do you have any significant trash-related problems and, if so, briefly describe. We are a raw water provider for a major metropolitan area. We have an algae problem in the summer. The algae breaks loose from the bottom of our regulating reservoirs and it is carried through the water supply system. The algae clogs downstream user's meters and increases the amount of byproduct after chlorine is added to the water.

3. Have you made any major changes to your methods of trash management over the past ten years? If so, briefly describe. No, we currently collect floating algae from a row boat or at the intake gates with racks.

4. Do you know to what extent your facilities are experiencing energy production losses or other economic losses as a result of trash accumulations? Very minimal. Most of our reservoir intakes are very deep and the trash does not get to the racks.

5. Do you use automatic trash raking equipment? If so, who is the manufacturer(s)? No mechanical cleaning equipment.

6. Do you keep data on amounts of trash – for example, tons removed annually (or other data)? No , but we manually remove several tons of wet algae from our tunnel gates/reservoir facility every year.

7. Does your organization budget or identify funds specifically for trash management? No, but we should.

8. Does trash arrive at your facility(ies) continually (year round), or seasonally? Mostly seasonally. This is due to the algae blooms in the summer as a result of more sunlight and higher water temperatures.

9. Would you be interested in participating in a future trash/debris management workshop or symposium? Yes.

Utility # 3

1. Are you entirely satisfied with your trash/debris practices, or do you think you may have significant opportunities for improvement?
We are reasonably pleased with what we do but there is always room for improvement.

2. Do you have any significant trash-related problems and, if so, briefly describe.
Not any longer. We did have significant sand deposition at our largest plant prior to the installation of a trash rack cleaning machine. (Supplemental information: In addition to its primary role in cleaning the trash racks, the Kuenz H-4000 machine helps to stir up the deposited sand and allow the sand to be flushed through the plant.)

3. Have you made any major changes to your methods of trash management over the past ten years? If so, briefly describe.
Yes. In 2003 we installed a hydraulic trash rack cleaning machine on our largest plant. (Supplemental information: Historical trash rack loss data and estimated benefits were used for quantifying benefits and justifying capital expenses for the trash rack cleaning machine.)

4. Do you know to what extent your facilities are experiencing energy production losses or other economic losses as a result of trash accumulations?
We do not track lost production due to trash rack losses. (Supplemental information: An analysis of pre-installation and post-installation trash rack loss data is underway to quantify the benefits from the trash rack cleaning machine.)

5. Do you use automatic trash raking equipment? If so, who is the manufacturer(s)?
We have a Kuenz H-4000 hydraulic trash rack cleaning machine at one of our three plants and use portable cranes and clam shells at the other two.

6. Do you keep data on amounts of trash – for example, tons removed annually (or other data)?
No (Supplemental information: Differential pressures across the trash racks are monitored and recorded. The data is used to schedule operation of the trash rack cleaning machine at one plant and to schedule manual cleaning at the other two plants.)

7. Does your organization budget or identify funds specifically for trash management?
No

8. Does trash arrive at your facility(ies) continually (year round), or seasonally?
Year round but the problem is much worse during high flow periods and during the fall/winter die-off period.

9. Would you be interested in participating in a future trash/debris management workshop or symposium?
Possibly.

Utility # 4

1. Are you entirely satisfied with your trash/debris practices, or do you think you may have significant opportunities for improvement?
I believe we still have significant opportunities for improvement.
2. Do you have any significant trash-related problems and, if so, briefly describe.
We still have manual "war wagon" style trashrakes at our smaller projects. These style rakes only rake four-feet of trashrack per cycle. By the time a mechanic uses the rake on the entire intake structure (140-feet in length) two hours have elapsed and the area where he started is again clogged with trash. We had an anonymous survey of our mechanics and one question was "what is the most dangerous task that you do?" The answer was "rake trash" in over 85% of the responses.
3. Have you made any major changes to your methods of trash management over the past ten years? If so, briefly describe.
Yes. Our larger projects now have automated trashrakes. Either the Dragrake style by North Fork Electric, or the gigantic "war wagon" style by Kunz.
4. Do you know to what extent your facilities are experiencing energy production losses or other economic losses as a result of trash accumulations?
Yes. We have data indicating that some of our sites with automatic trashrakes is now producing 12% more mwhs than before. Our worse performers are in the 7% range on a plant that historically produced 110,000 mwhs annually.
5. Do you use automatic trash raking equipment? If so, who is the manufacturer(s)?
Already answered.
6. Do you keep data on amounts of trash – for example, tons removed annually (or other data)?
No. We do maintain information on how much debris we remove from the lake of our pumped storage project using a "trash skimmer".
7. Does your organization budget or identify funds specifically for trash management?
Yes. Labor dollars for overtime.
8. Does trash arrive at your facility(ies) continually (year round), or seasonally?
Year round with the peak period being the fall because of leaves.
9. Would you be interested in participating in a future trash/debris management workshop or symposium?
Yes

Utility # 5

1. Are you entirely satisfied with your trash/debris practices, or do you think you may have significant opportunities for improvement?
Currently, we have a variety of practices depending on the facility. At two of our facilities, we have not trash rack cleaning systems nor is it presently required. Still, we do monitor the debris that does come down to keep track if we need to add trash cleaning equipment at these facilities. At some of our facilities, we are able to collect the trash that comes onto the dam, and then pass it downstream through a trash gate system.
At some of our facilities, we collect the trash and haul it off. Currently we utilize normal municipal or county removal agencies for this work and pay them to haul the debris to a landfill. At this time, these practices are not very onerous or expensive. We are not required to implement special handling of the trash and are able to utilize conventional means for disposal where we need to. We probably are in a case where we don't have significant opportunity for improvement on our existing system.
2. Do you have any significant trash-related problems and, if so, briefly describe.
No. The primary issue we had was the equipment we had used. We have been replacing our trash raking equipment with larger machinery and this has addressed most of the issues we had.
3. Have you made any major changes to your methods of trash management over the past ten years? If so, briefly describe.
As mentioned above, we have installed "automatic" trash raking systems or manually operated hydraulic trash rake equipment at our stations. This has significantly decreased the amount of time and labor required for this activity. While we do have several systems that are automatic, we currently do not run them remotely. We continue to have a person on-site while the trash handling process is ongoing.
4. Do you know to what extent your facilities are experiencing energy production losses or other economic losses as a result of trash accumulations?
We currently monitor trash build up by observing loss of generation or intake trash rack differentials. (Water level upstream of trash rack compared to the water level immediately downstream of the trash rack.) During the fall, when we have heavy debris loads, we will often remove trash based on efforts to maintain generating outputs at their peak. We keep track of this at our small plants. When we see this we will rake. We have differential monitoring
5. Do you use automatic trash raking equipment? If so, who is the manufacturer(s)?
Yes, we have used Cross Machine trash rakes but have more recently adopted Atlas Polar equipment as our preferred supplier.
6. Do you keep data on amounts of trash – for example, tons removed annually (or other data)?
No
7. Does your organization budget or identify funds specifically for trash management?
Currently, these costs are imbedded in our annual operating budgets are not specifically accounted for.
8. Does trash arrive at your facility(ies) continually (year round), or seasonally?
We experience a much heavier trash load in the fall when the leaves come down. During this period of time we will need to rake trash several times each day. Outside of that, raking frequency depends largely on rack differential warning or operator experience.
9. Would you be interested in participating in a future trash/debris management workshop or symposium?
We may be interested in this if something is put together that would involve general discussions and issues.

Utility # 6

1. Are you entirely satisfied with your trash/debris practices, or do you think you may have significant opportunities for improvement?
They could be improved.
2. Do you have any significant trash-related problems and, if so, briefly describe.
Being the last dam on a major river, we have a significant amount of floating debris that collects on the surface on the north side of the dam. It can literally cover acres of area and leads to problems with trash clogging our intakes for our units.
3. Have you made any major changes to your methods of trash management over the past ten years? If so, briefly describe.
No major changes.
4. Do you know to what extent your facilities are experiencing energy production losses or other economic losses as a result of trash accumulations?
Yes, at times our differential pressure will climb indicating that we are not getting appropriate flow through our trash racks.
5. Do you use automatic trash raking equipment? If so, who is the manufacturer(s)?
No, we did at one time.
6. Do you keep data on amounts of trash – for example, tons removed annually (or other data)?
Yes, we keep this information.
7. Does your organization budget or identify funds specifically for trash management?
Yes.
8. Does trash arrive at your facility(ies) continually (year round), or seasonally?
Continually, although the rainy seasons in the spring and fall are the worst.
9. Would you be interested in participating in a future trash/debris management workshop or symposium?
Yes.

Utility # 7

1. Are you entirely satisfied with your trash/debris practices, or do you think you may have significant opportunities for improvement?
We are presently satisfied with our trash/debris practices and do not have a need for improvement.
2. Do you have any significant trash-related problems and, if so, briefly describe.
During high flow or flood events (every 5-10 years), on one project, we can get large volumes of woody debris in our reservoir. We have two log booms to stop that debris from getting to the dam and turbine inlets. Using portable booms, we move the debris to a takeout point for sorting and processing with larger marketable timber sold, smaller debris offered to the public for firewood, and smaller debris burned.
3. Have you made any major changes to your methods of trash management over the past ten years? If so, briefly describe.
Other than more attention given to sorting out man-made debris for landfill disposal, no major changes.
4. Do you know to what extent your facilities are experiencing energy production losses or other economic losses as a result of trash accumulations?
We are not aware of any energy or generator related losses due to debris on our trash racks.
5. Do you use automatic trash raking equipment? If so, who is the manufacturer(s)?
We have manually operated trash rakes on several sites.
6. Do you keep data on amounts of trash – for example, tons removed annually (or other data)?
We have a general idea on trash volumes by year but no specific records.
7. Does your organization budget or identify funds specifically for trash management?
Trash removal is incorporated into our normal O&M budget. For extraordinary years, we will seek additional, special funding.
8. Does trash arrive at your facility(ies) continually (year round), or seasonally?
Usually trash arrives seasonally during periods of higher flows bringing down floating debris that would otherwise be above the normal water level.
9. Would you be interested in participating in a future trash/debris management workshop or symposium?
Probably not at this point in time.

Utility # 8

1. Are you entirely satisfied with your trash/debris practices, or do you think you may have significant opportunities for improvement?
We have made many improvements with logbooms, sluice gates, rakes, etc. We still have improvements needed at the stations where trash has the most impact.
2. Do you have any significant trash-related problems and, if so, briefly describe.
Our problems are mostly on the long run of rivers that have the least development during high water events.
3. Have you made any major changes to your methods of trash management over the past ten years? If so, briefly describe.
We have added new rakes at two stations, heavy logbooms at three stations, and one sluice gate. We also have equipment to remove sub-surface build up.
4. Do you know to what extent your facilities are experiencing energy production losses or other economic losses as a result of trash accumulations?
We may loose 1 or 2 MW off the
Verticles or completely shutdown the small horizontals.
5. Do you use automatic trash raking equipment? If so, who is the manufacturer(s)?
We have one new installation built by North Fork Electric.
6. Do you keep data on amounts of trash – for example, tons removed annually (or other data)?
No.
7. Does your organization budget or identify funds specifically for trash management?
We have in house labor budgeted with a portion of their time allocated to remove trash.
8. Does trash arrive at your facility(ies) continually (year round), or seasonally?
Seasonally.
9. Would you be interested in participating in a future trash/debris management workshop or symposium?
Yes.

Utility # 9

1. Are you entirely satisfied with your trash/debris practices, or do you think you may have significant opportunities for improvement?
Automated trash rakes at several locations would reduce physical manpower requirements.
2. Do you have any significant trash-related problems and, if so, briefly describe.
Several Mississippi River watershed hydroplants have significant weed and leaf periods in late summer and fall requiring rack raking several times each day.
3. Have you made any major changes to your methods of trash management over the past ten years? If so, briefly describe.
Spillway gates adjacent to the powerhouse were modified at 2 plants in order to be able to flush the weeds & leaves without removing them from the river. For one station, an inflatable dam replaced a section of flashboards. For the other, a set of wooden stoplogs was replaced with a two-section motor operated slide gate. For trash sluicing, the upper section is raised to pass the weeds & leaves. When the gate is needed to pass higher river flows, the upper section is bolted to the lower section and the entire gate is raised. Generating units are motored, allowing debris to float as flow is shut off through the units successively, moving the debris to the nearest spillway gate. Compressed air is bubbled through wands stuck through mats of weeds to help float them away. The latest license we have been issued has an Article requiring the passing of large woody debris through a reservoirs spillway gates for habitat in the downstream rapids. Licenses obtained earlier only required the removal of un-natural material.
4. Do you know to what extent your facilities are experiencing energy production losses or other economic losses as a result of trash accumulations?
The losses would be very difficult to quantify. Three plants that see the large quantities of leaves & weeds will show a gradual decrease in generation and an increase in trashrack differential. Maintenance is then called out, the units are motored for 15 minutes while the racks are raked, and the cycle starts again.
5. Do you use automatic trash raking equipment? If so, who is the manufacturer(s)?
No.
6. Do you keep data on amounts of trash – for example, tons removed annually (or other data)?
No.
7. Does your organization budget or identify funds specifically for trash management?
Ordinary trash removal is considered as part of normal operation & maintenance expense for each station. Work orders are established to track costs associated with one-time projects such as dredging to remove sunken woody debris in front of a powerhouse or disposal of multiple years of accumulated debris from a station.
8. Does trash arrive at your facility(ies) continually (year round), or seasonally?
Logs, trees, & woody debris in small quantities throughout the ice-free season, large quantities in the spring runoff, leaves & weeds in late summer & fall.
9. Would you be interested in participating in a future trash/debris management workshop or symposium?
No.

Utility # 10

1. Are you entirely satisfied with your trash/debris practices, or do you think you may have significant opportunities for improvement? We have limit future opportunities for significant benefits since we have made a number of improvements since 2000. I will be referring to our two largest projects (18 units, 600 MW; 11 units, 1300 MW).

2. Do you have any significant trash-related problems and, if so, briefly describe. We currently estimate we are loosing about $1,000,000 per year at the smaller project and $1,500,000 per year at the larger project. Of those losses, we have determined we can feasibly recover about $500,000 per year at the smaller project and $250,000 per year at the larger project.

3. Have you made any major changes to your methods of trash management over the past ten years? If so, briefly describe. We have installed trashrack loss monitoring equipment (2001) at both hydro projects and started a trashrack replacement project at the smaller project. At both projects, we clean much more frequently, based on the differentials, using a clam bucket and divers. The new trashracks have a wider bar spacing and improved hydraulic profile (lower clean rack losses). Also at the smaller project, we have executed a contract to install a new trash rake/cleaner in 2008 (manufactured by Muhr – Brannenburg, Germany).

4. Do you know to what extent your facilities are experiencing energy production losses or other economic losses as a result of trash accumulations? Yes – see above.

5. Do you use automatic trash raking equipment? If so, who is the manufacturer(s)? We have automated traveling screens and trash rakes on our adult and juvenile fish bypass systems, but none on the generating unit intakes (yet – see above). Manufactures of the trash rakes included Atlas Polar and Kenix both of which have been replaced by a custom built unit.

6. Do you keep data on amounts of trash – for example, tons removed annually (or other data)? No. Just labor and equipment costs annually.

7. Does your organization budget or identify funds specifically for trash management? No.

8. Does trash arrive at your facility(ies) continually (year round), or seasonally? Large/noticeable amounts are seasonally or large runoff event related.

9. Would you be interested in participating in a future trash/debris management workshop or symposium?
Yes

Utility # 11

1. Are you entirely satisfied with your trash/debris practices, or do you think you may have significant opportunities for improvement? We have limit future opportunities for significant benefits since we have made a number of improvements since 2000. I will be referring to our two largest projects (18 units, 600 MW; 11 units, 1300 MW).

2. Do you have any significant trash-related problems and, if so, briefly describe. We currently estimate we are loosing about $1,000,000 per year at the smaller project and $1,500,000 per year at the larger project. Of those losses, we have determined we can feasibly recover about $500,000 per year at the smaller project and $250,000 per year at the larger project. (Supplemental information: A trash barrier, designed using hydraulic model tests, has been installed upstream from the larger project to divert oncoming debris to the shore where it can be handled using a clam bucket.)

3. Have you made any major changes to your methods of trash management over the past ten years? If so, briefly describe. We have installed trashrack loss monitoring equipment (2001) at both hydro projects and started a trashrack replacement project at the smaller project. At both projects, we clean much more frequently, based on the differentials, using a clam bucket and divers. The new trashracks have a wider bar spacing and improved hydraulic profile (lower clean rack losses). Also at the smaller project, we have executed a contract to install a new trash rake/cleaner in 2008 (manufactured by Muhr – Brannenburg, Germany).

4. Do you know to what extent your facilities are experiencing energy production losses or other economic losses as a result of trash accumulations? Yes – see above.

5. Do you use automatic trash raking equipment? If so, who is the manufacturer(s)? We have automated traveling screens and trash rakes on our adult and juvenile fish bypass systems, but none on the generating unit intakes (yet – see above). Manufactures of the trash rakes included Atlas Polar and Kenix both of which have been replaced by a custom built unit.

6. Do you keep data on amounts of trash – for example, tons removed annually (or other data)? No. Just labor and equipment costs annually.

7. Does your organization budget or identify funds specifically for trash management? No.

8. Does trash arrive at your facility(ies) continually (year round), or seasonally? Large/noticeable amounts are seasonally or large runoff event related.

9. Would you be interested in participating in a future trash/debris management workshop or symposium?
Yes

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