Appendix F

Generation Capability Assessment Report: Volume II – Swift No. 1 Project

FINAL DRAFT

GENERATION CAPABILITY ASSESSMENT REPORT
LEWIS RIVER HYDROELECTRIC PROJECTS
FERC Project Nos. 2111, 2213, 2071 and 935

VOLUME II

Swift No. 1 Project

FERC Project No. 2111

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VOLUME II - SWIFT NO. 1

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1.0 GENERAL OPERATING CONDITIONS

1.1 Headwater Level

The Swift Reservoir is operated in coordination with the Yale and Merwin reservoirs to provide flood regulation in the Lewis River basin; to accommodate recreation; and to schedule generation to match PacifiCorp's system requirements. Cowlitz PUD, owner of the Swift No. 2 Project, operates a portion of the Swift Reservoir via a "paper pond" account, and uses that portion of the reservoir to schedule generation (through PacifiCorp) to meet the needs of the Cowlitz PUD system. The normal maximum and minimum Swift Reservoir elevations are shown in Table 1.1-1.

Table 1.1-1. Normal Swift Reservoir operating levels.

Description	Reservoir Elevation (ft)
Normal maximum	1000
Normal minimum (summer)	995
Normal minimum	925

1.2 Tailwater Level

The Swift No. 1 powerhouse discharges into a 3½ mile long canal which delivers water to the Swift No. 2 intake and powerhouse. The canal includes an ungated overflow spillway, wasteway, and discharge channel which prevent canal flows from exceeding the Swift No. 2 hydraulic capacity and maintain the maximum level in the canal. The minimum canal water surface elevation at the Swift No. 1 tailrace depends on the number of units in operation. Typical operating levels are shown in Table 1.2-1.

Table 1.2-1. Normal Swift No. 1 tailwater (Swift No. 2 canal headwater) levels.

Description	Tailwater (Canal) Elevation (ft)
Normal maximum (wasteway spillway crest elevation)	604
Normal minimum (1-unit operation)	602
Normal minimum (2-unit operation)	603
Normal minimum (3-unit operation)	604

1.3 Head Loss

Water to the Swift No. 1 powerhouse is delivered from the dam through a tunnel, surge tank, three branched tunnel outlets, and three penstocks (one each for the three Swift No. 1 units). The head loss from the intake to each unit, then, is a function of the total powerplant flow and the distribution of flow between the units. Head loss coefficients for one, two, and three-unit operation determined in part by the 1960 index test results and described in the 1990 Lewis River Upgrade Study Reports are shown in Table 1.3-1.

Table 1.3-1. Swift No. 1 head loss coefficients.

Description	Head Loss Coefficient K[1] (ft)
One unit operation	9.0 E-7
Two unit operation	12.69 E-7
Three unit operation	18.84 E-7
1. Total head loss = K * (unit flow in cfs)^2	

1.4 Maximum Net Head

The maximum net heads seen by the Swift No. 1 turbines under one, two, and three-unit operation are shown in Table 1.4-1. The maximum net head is based on an estimated turbine hydraulic capacity of 3,040 cfs for each of the three units (turbine performance data is provided in Section 2).

Table 1.4-1. Maximum net head for one, two, and three-unit operation at Swift No. 1

Description	One Unit Operation	Two Unit Operation	Three Unit Operation
Maximum headwater elevation (ft)	1000	1000	1000
Minimum tailwater elevation (ft)	602	603	604
Estimated head loss (ft)	8	12.5	18
Maximum net head (ft)	390	384.5	378

All of the turbine-generator performance and capability data presented in Section 2 and Section 3 are based on the maximum net head under three unit operation.

2.0 EXISTING CAPABILITY

2.1 Water Delivery System

Water is delivered to the Swift Reservoir to the Swift No. 1 powerplant via an intake and tunnel, surge tank, and individual penstocks for each of the turbine-generators.

2.1.1 Intake/Tunnel

The Swift No. 1 intake can be classified as a deep, relatively high-head intake. Design velocities typically range between 10 and 20 feet per second. Based on the tunnel inlet diameter (25 ft) and the minimum water surface elevation in the Swift Reservoir, the intake is capable of passing more than 150 percent of the existing plant hydraulic capacity without forming vortices according to industry standard criteria (e.g.; Gordon's criteria). The reasonable limit to the intake and tunnel flows would ultimately be related to acceptable head losses and penstock pressure rise limits. To date, the intake and tunnel at Swift No. 1 have operated satisfactorily without vortex formation or excessive head loss. As a result, study engineers estimate the existing overload capability at 120 percent of the existing capacity. The existing and acceptable overload capabilities are summarized in Table 2.1-1.

Table 2.1-1. Swift No. 1 intake/tunnel capability.

Description	Capability		
	Flow (cfs)	Velocity[2] (ft/sec)	Output (kW)
Existing capability[1]	9,120	18.6	263,400
Acceptable overload	10,940	22.3	314,300

1. Based on the existing maximum powerplant flow (see Section 2.2)
2. At the tunnel inlet

2.1.2 Surge Tank

The Swift No. 1 surge tank is located approximately 1,196 feet downstream of the tunnel intake and about 482 feet upstream of the powerhouse. The surge tank is of the restricted orifice, non overflow style with a diameter of 55 feet and a top elevation of 1035 ft. Downstream of the tank, individual penstocks for each generating unit branch from the main tunnel. Study staff were not successful in locating test data indicating the maximum water surface in the surge tank during full plant load rejections (three units at 100 percent gate). Accordingly, engineers made a preliminary estimate of the tunnel flow which could be tolerated without overtopping the surge tank. This assessment assumes that the head loss in the hydraulic system up to the tank is proportional to the distance to the tank and that the differential surge level is proportional to the square of the total tunnel flow. Also, engineers assumed that 10 feet of freeboard currently exists in the tank under full load rejection conditions.

Based on these assumptions, the surge tank overload capacity (the tunnel flow which can be tolerated without overtopping the tank) is approximately 111% of the existing three unit maximum flow. This capacity does not consider the pressure rise capability of the penstocks or tunnel liner (the penstock pressure rise is addressed in Section 2.1.3). If the existing surge tank freeboard during a plant load rejection is less than 10 feet, the overload flow which can be achieved without overtopping the tank will be less than described above. The capacity of the surge tank under several different existing freeboard assumptions is presented in Table 2.1-2.

Table 2.1-2. Surge tank hydraulic capacity based on assumed surge tank freeboard

Assumed freeboard for current plant full-load rejection (ft)	Maximum Tunnel Flow with zero freeboard during plant full-load rejection (cfs)
5	9,580
10	10,120

2.1.3 Penstocks

Each of the Swift No. 1 penstocks is 13 feet in diameter. At maximum turbine flows, the existing penstocks reach velocities of up to almost 23 feet per second. While these velocities are higher than current industry design velocities, the penstocks have operated satisfactorily without excessive head loss since their installation. Also, the total penstock length (from the surge tank to each individual unit) is relatively short there are no bifurcations or branches in the highest velocity sections. As a result, study engineers estimate the acceptable overload capability at 120 percent of the existing maximum flow. The capabilities are summarized in Table 2.1-3.

Table 2.1-3. Swift No. 1 penstock capabilities.

Description	Capability		
	Flow (cfs)	Velocity (ft/sec)	Output (each penstock) (kW)
Existing capability[1]	3,040	22.9	87,800
Acceptable overload	3,650	27.5	115,500
1. Based on the existing maximum powerplant flow (see Section 2.2)			

Note that an increase in the maximum penstock flow would result in increased penstock pressures during load rejections. The increase in pressure loading would be generally proportional to the square of the velocity, assuming that no changes are made in wicket gate timing or turbine hydraulic characteristics (note that replacement turbine runners will likely have different runaway discharge and choking flow characteristics). Study engineers have completed only a cursory transient analysis to estimate the maximum instantaneous penstock pressure rise during a load rejection. Based on this analysis, the pressure rise with the existing maximum flow is on the order of 30 percent of the gross head. With the overload flow shown in Table 2.1-3, the pressure rise is expected to be less than 40 percent of the gross head. Study engineers have assumed that this increase in pressure rise is within the reasonable limit of the penstocks.

2.2 Turbine-Generators

2.2.1 Turbine-Generator Performance

The Swift No. 1 turbine-generators were index tested in 1960 following their installation. The index tests measured the relative performance of the turbine-generators. By assuming that the peak efficiency measured during the index test is equal to the manufacturer's predicted or guaranteed peak efficiency, the index test data were used to estimate the absolute turbine-generator efficiencies. In December 1989, PacifiCorp's engineering consultant measured the Unit 2 generator output over the full range of servomotor strokes and compared these power-gate test data with the 1960 index test data to estimate the degradation in turbine-generator efficiency since installation. Given the available data and the difficulty in measuring flow to each unit, this method provides a reasonable estimate of the existing turbine-generator efficiencies. The 1989 measured turbine-generator performance data are summarized in Table 2.2-1.

Table 2.2-1. Swift No. 1 Unit 2 output vs. servomotor stroke test summary (1989 power-gate tests).

Servomotor Stroke (in)	Gross Head (ft)	Generator Output (kW)
7.22	370.12	48,580
7.30	370.17	49,000
8.95	370.08	64,400
11.35	370.13	79,110
11.75	370.10	81,320

The 1990 Lewis River Upgrade Study report concluded that the differences in output between the data measured in 1960 and the data measured in 1989 were within the accuracy of the testing methods and, as a result, that the performance of the units had not changed since 1960. Study engineers for the 1996 GCA agree that it is very difficult to conclusively quantify the change in turbine-generator performance given the existing test data. Any comparison of the 1960 and 1989 data is limited by potential differences in measurement methods and inaccuracies in the measured data (including wicket gate position, headwater and tailwater elevations and watt-hour meter calibrations). However, the data available allow a general comparison between the units' performance in 1960 and their performance in 1989 as discussed below.

Study engineers conducted a brief statistical review of the 1960 and 1989 data to determine if there was any evidence of a measurable change in the units' performance since installation. Engineers corrected Swift No. 1 Unit 2 data from 1960 and 1989 to a common gross head of 395 feet (as was done in the 1990 study report) and fit each data set with a third-order polynomial equation. These data are presented in Figure 2.2-1. The R-squared value for each of these curve-fits is greater than 0.997 (the R-squared value is a measure of the statistical similarity, or correlation, of the curve-fit to the data points; an R-squared value of 1.0 indicates a perfect correlation of the curve-fit to the data). By comparing the generator output predicted by the each of these curve-fit equations over the range of measured servomotor strokes, engineers attempted to estimate the degradation in turbine-generator performance from 1960 to 1989. This statistical evaluation suggests

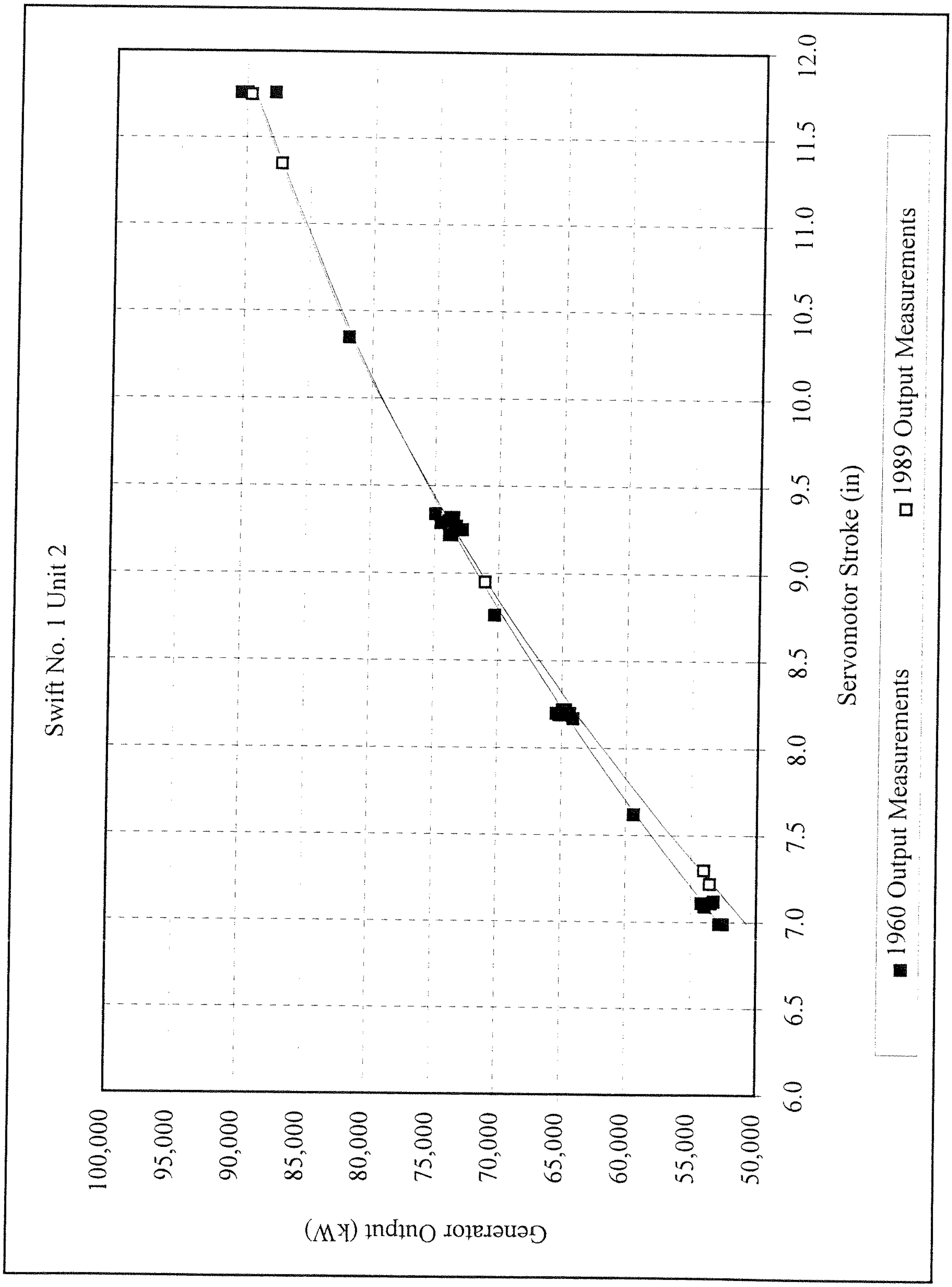

Figure 2.2-1. Swift No. 1 Unit 2 power-gate test results.

that the generator output at servomotor strokes of around 7-inches (approximately 60 percent gate) had degraded approximately 4 percent since installation. The degradation appears to decrease with increasing servomotor stroke up to 100 percent gate (refer to Figure 2.2-1).

It is very difficult to quantify the errors in this type of evaluation. The current statistical analysis suggest a change in the shape of the efficiency curve for Swift No. 1 Unit 2 which may be due to an actual change in efficiency. If the 1960 and the 1989 data were each measured to within ±2 percent, however, then the 4 percent difference in output at 60 percent gate would be statistically insignificant. Based on study engineers' evaluations of other units efficiency degradation over time and the recurring cavitation damage and regular repairs to the Swift units documented in the 1990 upgrade study report, though, a ½ to 1-percent degradation in efficiency per decade of operation is not unreasonable for a machine of this size, vintage, and original design. The statistical comparison of the 1960 and 1989 test data (although limited in its accuracy) suggests that the efficiency of the Swift No. 1 units may have degraded somewhat between approximately 60 and 80 percent gate opening.

It is important to note the possible degradation in the Swift turbine performance for two reasons. First, the Swift inflows are back-calculated in part from the PacifiCorp's hourly reservoir and generation records. Consequently, inaccuracies in the existing performance data could produce errors in the hydrology data. In effect, overstating the efficiency would result in a lower calculated discharge through the project than may actually be the case. This type of error would not measurably effect the estimated benefits of efficiency upgrades but would have an impact on capacity upgrades. Second, the existing performance is the baseline against which the upgrade alternatives are compared.

The uncertainties in the existing efficiency data impact study engineers' confidence in the GCA study results. It is possible, for example, that the initial 1960 turbine-generator performance at Swift No. 1 fell short of the manufacturer's design efficiency (of approximately 91.2 percent) by 1 percent, and that the turbines have suffered a loss in operating efficiency of 2.6 percent (approximately 0.75 percent per decade) since their installation. The combination of these factors would result in a peak turbine-generator efficiency of 87.6 percent. Turbine manufacturer's data suggests that a replacement turbine runner at Swift No. 1 could achieve a peak efficiency of 94.8 percent. This results in a peak combined turbine-generator efficiency of approximately 92.4 percent. Depending on the actual existing performance, the new runner might increase the peak efficiency by as much as 4.8 percent (92.4-87.6) or as little as 1.2 percent (92.4-91.2). The uncertainty associated with the change in peak efficiency in this example would similarly be reflected in the estimated energy benefits of this runner replacement.

The previous discussion describes the significance of the existing efficiencies in the upgrade analyses. As a result of this significance, study engineers completed an additional, independent analysis aimed at identifying potential changes and/or errors in the existing efficiency data. This analysis was based on the Lewis River flows measured at the USGS gage below Merwin and on PacifiCorp's historical reservoir levels from 1991. The results of this second analysis includes a complete record of daily Swift No. 1 turbine discharges for 1991. By comparing these independently calculated discharges with the discharges stored in PacifiCorp's KWH accounting system (which were determined from the existing performance data), engineers can locate potential errors/inaccuracies in the performance data, if they exist. This analysis did not reveal any apparent errors in the assumed performance of the existing Swift No. 1 units.

In summary, study engineers completed two separate analyses in an effort to better define the existing performance of the Swift No. 1 turbine generators. The first analysis was a statistical evaluation of the power-gate test data. This analysis suggested that the Swift No. 1 units' performance may have degraded over time, particularly between 60 and 80 percent gate. The potential errors in this analysis, however, were of the same order of magnitude as the estimated change in performance. The second analysis did not indicate any measurable change in the units' performance. As a result of these analyses, study engineers can neither prove nor disprove that the existing performance of the Swift units is any different from the original, expected performance. To be conservative, then, study engineers have used the original, expected performance as the baseline for all the upgrade evaluations. This assumption may underestimate the benefits of the upgrade options investigated and is consequently considered conservative.

If plant outages are contemplated at Swift No. 1 for any reason, then the addition of flowmeters on the unit penstocks or in the main tunnel should be considered. Accurate measurement of the Swift No. 1 flows would allow a detailed evaluation of the existing units' efficiencies and a more confident determination of the upgrade benefits. Study engineers suspect that the actual benefits of the upgrades may be more than shown in this report.

Figure 2.2-2 and Table 2.2-2 present the range of expected turbine-generator performance for the Swift No. 1 units. The upper efficiency curve shown in Figure 2.2-2 is based on the 1960 index test results and is considered the maximum probable performance of the existing units. This is the performance used in the upgrade evaluations (see Section 3). The lower curve is based on applying the turbine efficiency degradation predicted by the statistical evaluation over the range of operation. The data shown do not reflect any adjustments to account for possible changes in the performance since 1989.

Note that the performance data presented is based on performance data measured on Unit 2. Recent performance data for the other units is not available; the performance of Unit 2 is consequently considered representative of all three units.

Table 2.2-2. Swift No. 1 turbine-generator performance at 378 feet net head.

Turbine Flow (cfs)	1960 Performance[1]		1989 Performance[2]	
	Generator Output (kW)	Net Turbine-Generator Efficiency (%)	Generator Output (kW)	Net Turbine-Generator Efficiency (%)
1,400	35,249	78.7%	33,873	75.7%
1,700	45,585	83.9%	43,805	80.6%
2,000	55,968	87.5%	54,231	84.8%
2,300	66,157	89.9%	65,384	88.9%
2,600	75,596	90.9%	75,483	90.8%
2,800	81,630	91.2%	81,786	91.3%
2,900	83,867	90.4%	84,010	90.6%
3,000	86,572	90.2%	86,697	90.4%
3,040	87,679	90.2%	87,797	90.3%

1. Performance estimated from 1960 index tests.
2. Performance estimated from statistical evaluation of 1989 generator output data.

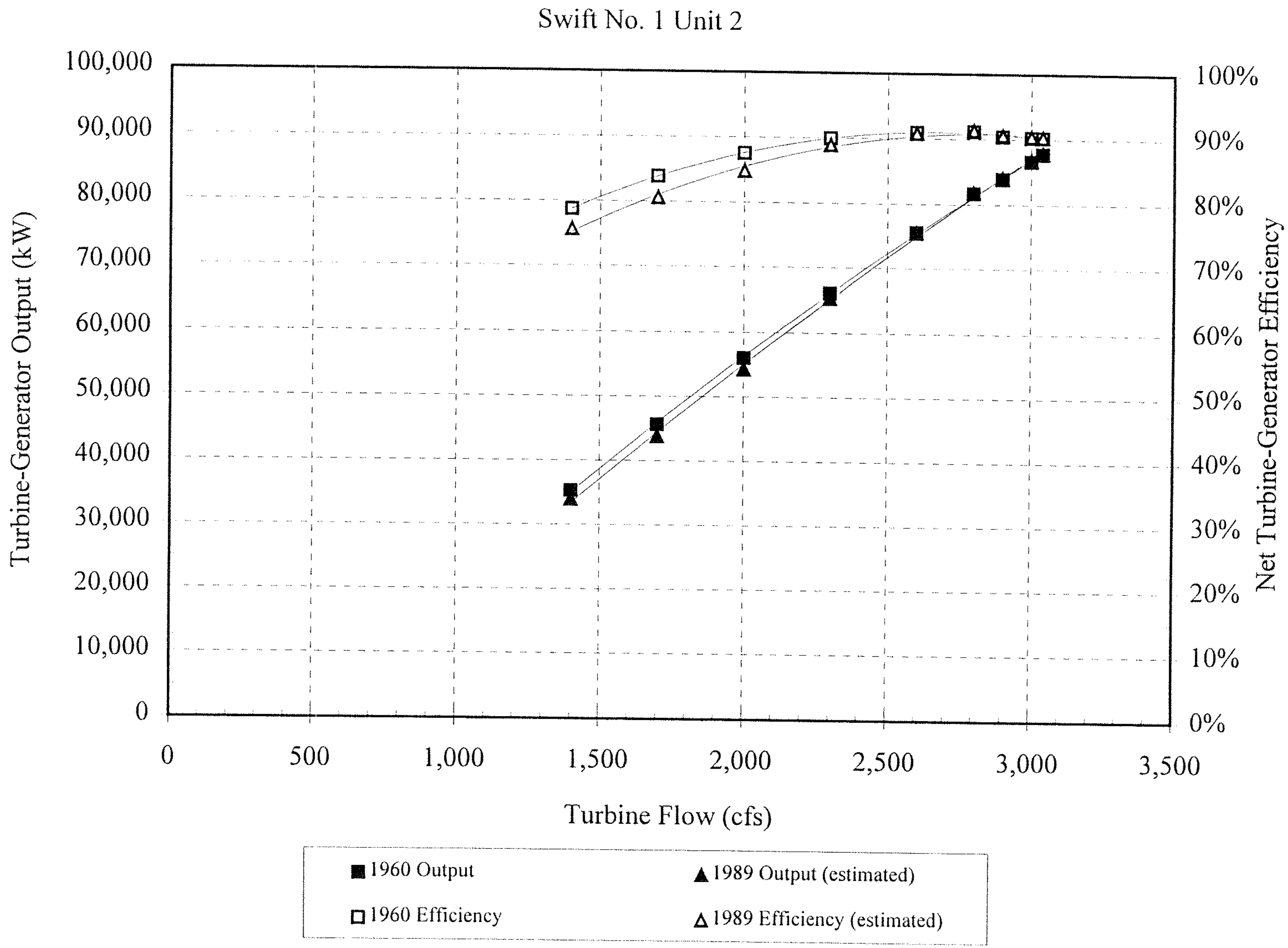

Figure 2.2-2. Swift No. 1 turbine-generator performance.

2.2.2 Turbine Capability

The Swift No. 1 turbine capability is taken as the generator output when the turbine is operating at 100 percent gate. The Swift No 1 turbine capabilities are summarized in Table 2.2-3. Note that the generator efficiency is necessarily included in the turbine capability. The turbine efficiency (independent of the generator) is shown at best gate and full gate for comparison with the performance of potential upgrades (see Section 3). Also note that the turbine capability shown is based on the statistical evaluation of the 1989 output measurements. The turbine capability (kW) is very nearly the same regardless of whether its estimated from the 1960 index test data or the statistical evaluation of the 1989 output measurements described in Section 2.2.1. The hydraulic capacity and efficiencies, however, are different depending on the method chosen (See Section 2.2.1).

Table 2.2-3. Swift No. 1 turbine-generator performance summary at 378 feet net head.

Description	Turbine Flow (cfs)	Generator Output (kW)	Net Turbine-Generator Efficiency	Generator Efficiency[1]	Turbine Efficiency[2]
Best Gate	2,800	81,800	91.3%	97.5%	93.7%
Full Gate	3,040	87,800	90.3%	97.5%	92.6%
Plant Capacity[3]	9,120	263,400	NA	NA	NA

1. Estimated
2. Based on statistical evaluation of 1989 generator output measurements.
3. All 3 units operating at 100 percent gate.

2.3 Generator

The Swift No. 1 generators were installed in 1958 and rewound in 1987, 1990, and 1991 (units 2, 1, and 3, respectively). Original and existing nameplate ratings are shown in Table 2.3-1.

Table 2.3-1. Swift No. 1 generator nameplate ratings.

Unit	Original Nameplate Data					Existing Nameplate Data				
	Rating			Insulation Class	Temp. Rise[1] (°C)	Rating			Insulation Class	Temp. Rise[1] (°C)
	(kVA)	P.F.	(V)			(kVA)	P.F.	(V)		
1	75,555	0.9	13,800	B	50	90,000	0.9	13,800	F	60
2	75,555	0.9	13,800	B	50	90,000	0.9	13,800	F	60
3	75,555	0.9	13,800	B	50	90,000	0.9	13,800	F	60

1. PacifiCorp's imposed temperature rise limits, over a 40°C ambient temperature.

Heat rise tests were not conducted on the Swift No. 1 generators. However, study engineers reviewed the Swift No. 1 operating logs for the periods from November 18 through December 5, 1995, and January 26 through February 20, 1996. In late November and/or early December, all three Swift No. 1 units apparently operated at or near 100 percent gate for 2 to 3 days. Operating logs for units 1 and 2 indicate average stator temperatures between 80 and 85°C; stator temperatures for Unit 3 were not recorded during this period. Unit 1 and 2 outputs during this period ranged between 86 and 88 MW at approximately unity power factor. Generator cooling air temperatures are not consistently included on the recording logs and, consequently, are not available. Based on an assumed nominal cooling air temperature between 30 and 35°C, engineers estimate the generator temperature rise between 45 and 55°C. Interviews with PacifiCorp electrical staff revealed that the three Swift No. 1 units have historically operated with total stator temperatures of about 80°C (between approximately 86 and 88 MW). PacifiCorp allows a maximum stator temperature of around 90°C. With this stator temperature limit, the generators could produce the overload output shown in Table 2.3-2 continuously, even during the summer. PacifiCorp staff also reported that Unit 2 has suffered some stator winding deterioration due to both high stator temperatures and high corona activity in the stator windings. However, this deterioration is not severe enough to warrant a reduced generator limit for Unit 2.

The Swift No. 1 generator capabilities are summarized in Table 2.3-2.

Table 2.3-2. Swift No. 1 generator capability.

Unit	Capability at Unity Power Factor (kW, each unit)	
	Nameplate Capability (Rewound)	Acceptable Overload
Unit 1	90,000	95,000
Unit 2	90,000	95,000
Unit 3	90,000	95,000

The Swift No. 1 units are equipped with modulating cooling water valves which restrict water flow to the air coolers in order to maintain near constant stator winding temperatures. PacifiCorp staff recently determined that the existing 4-inch cooling water control valves restrict the cooling water flows to the generators. PacifiCorp plans to replace the 4-inch valves with 6-inch valves to allow higher cooling water flow rates. It may be possible to modulate the cooling water system in such a way that the rated temperature rise is exceeded, but the stator winding temperature limit is not (see Section 3). The allowable temperature rise can be confirmed by tests following installation of the new control valves.

2.4 Generator Switchgear and Bus

Power from the Swift No. 1 generators is transmitted at generator voltage via isolated phase bus ducts directly to the step-up transformers located on the transformer deck of the powerhouse immediately over the tailrace. From the step-up transformers, power is transmitted via 230 kV overhead lines to the switchyard where circuit breakers are provided for the generating units in a ring bus configuration. Consequently, no generator switchgear exists in the system at generator voltage (13.2 kV). The isolated phase bus ducts are comprised of one 6-inch by 6-inch by 3/8-inch tubular copper bar per phase.

In addition to the isolated phase bus duct, manual disconnect links are provided on the Unit 1 and Unit 3 13.2 kV buses for maintaining power to the step up transformers during generator maintenance. A similar motor-operated switch is provided in the Unit 2 bus. Also, manual disconnect switches are located on the 230 kV side of each transformer to isolate the transformer from the ring bus during transformer maintenance.

The generator bus, bus link, disconnect switch and circuit breakers ratings are shown in Table 2.4-1. Study engineers assume that the manual disconnect links have similar ratings to the adjoining bus. Note that, in the switchyard's ring bus arrangement, two of the individual circuit breakers and several of the disconnect switches could be required to carry the full output of both the Swift No. 1 and Swift No. 2 powerplants. Study staff believe that the individual unit disconnect switches and circuit breakers were installed with the high ratings shown to maintain a common design for all like equipment in the switchyard.

Table 2.4-1. Swift No. 1 generator bus and bus link ratings.

Unit	Description	Nameplate Rating[1]		
		(A)	(kV)	(kVA)
Units 1, 2 and 3	Isolated phase bus duct	4,500	13.2	105,000[2]
Units 1, 2 and 3	Bus disconnect links	4,500	13.2	105,00[2,3]
Units 1, 2 and 3 (combined)	Disconnect switch	1,200	230	478,000[4]
Units 1, 2 and 3 (combined)	Circuit breakers	2,000	230	797,000[4]

1. Based on review of project drawings.
2. Each unit.
3. To be confirmed.
4. Total plant.

2.5 Transformer

The Swift No. 1 transformer data is summarized in Table 2.5-1.

Table 2.5-1. Swift No. 1 transformer data.

Unit	Manufacturer	Rating (kVA)	Temp. Rise (°C)	Cooling Type/ Class
1	G.E./U.S. Transformer West, Inc.	87,000/100,000	55/65	FOA
2	General Electric	87,000	55	OW
3	General Electric	87,000	55	OW

Transformer oil temperatures are not recorded on the Swift No. 1 operating logs. However, PacifiCorp staff report that the transformer winding temperatures at 85,000 kW and a 90°F (32°C) ambient air temperature are 69°C (Unit 1) and 70°C (units 2 and 3). PacifiCorp staff prefer to operate the transformers with a maximum winding temperature of 80 to 85°C.

Barring unusual conditions, study engineers would normally expect that the transformers could be overloaded without sacrificing their life expectancy during periods when the daily average ambient temperature is less than 30°C. The temperature data provided above suggests that it may be possible to overload the Swift No. 1 transformers even when the ambient air temperatures exceed 30°C. Transformer overload capabilities are summarized in Table 2.5-2.

Table 2.5-2. Swift No. 1 transformer capabilities.

Unit	Nameplate Rating (kVA)	Acceptable Overload[1] (kVA)
1	100,000[1]	105,000[1]
2	87,000[2]	91,350[2]
3	87,000[2]	91,350[2]

1. Based on 65°C temperature rise.
2. Based on 55°C temperature rise.

2.6 Project Capability

The existing generating capability of Swift No. 1 units 1, 2, and 3 are shown in Figures 2.6-1, 2.6-2, and 2.6-3, respectively.

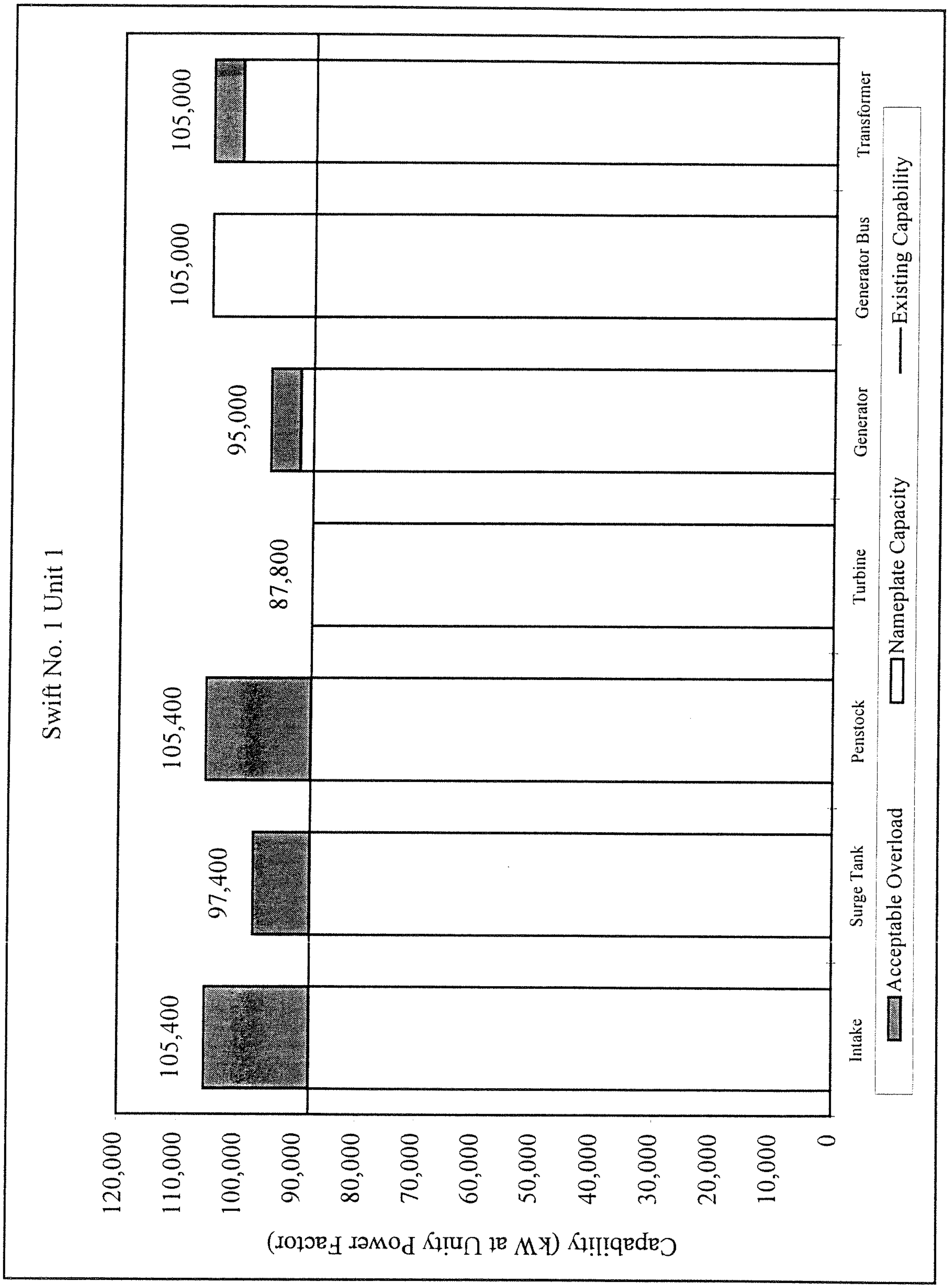

Figure 2.6-1. Existing Swift No. 1 Unit 1 generation capability.

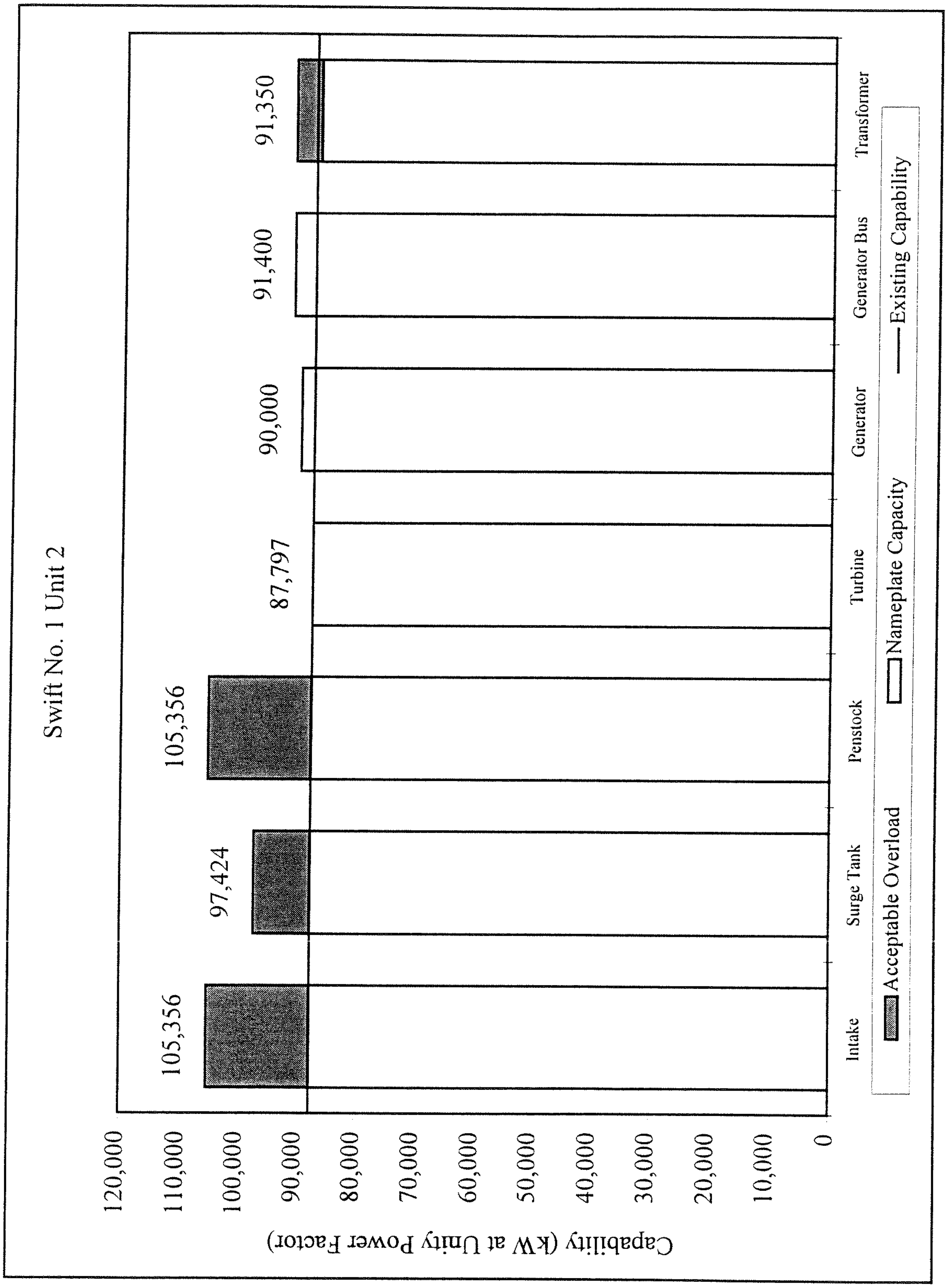

Figure 2.6-2. Existing Swift No. 1 Unit 2 generation capability.

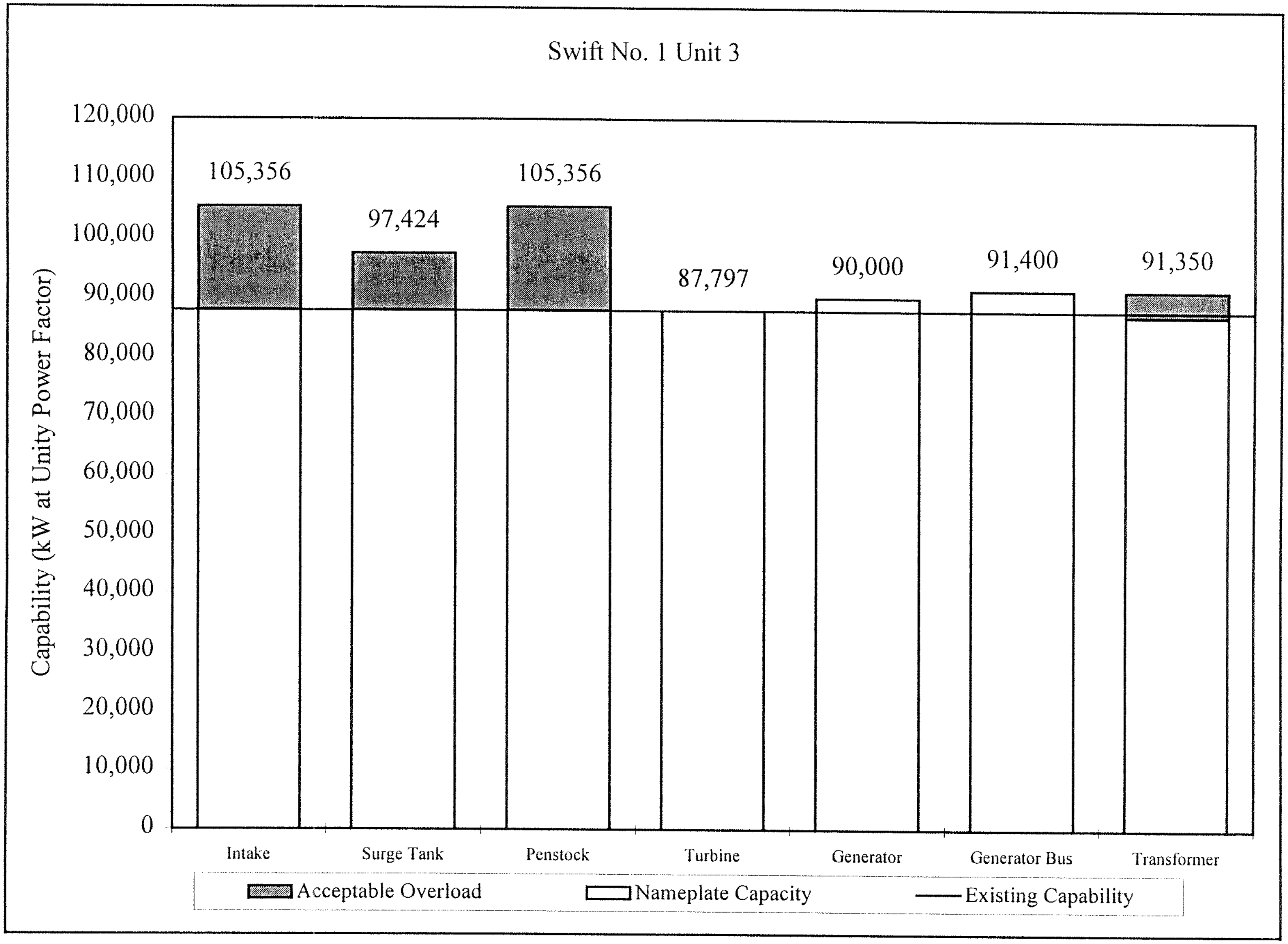

Figure 2.6-3. Existing Swift No. 1 Unit 3 generation capability.

3.0 UPGRADE ALTERNATIVES

3.1 Operational Alternatives

The Swift Reservoir is fluctuated on a seasonal basis to help regulate seasonal inflows. In addition, the Swift Reservoir is fluctuated to a much smaller extent to allow peaking operation of Swift No. 1 and Swift No. 2. Daily and weekly off-peak inflows are stored in the reservoir, raising the level. During the peak period, the reservoir is drawn to augment inflows and allow operation of the turbine-generators at high loads near peak efficiency. The reservoir fluctuates to continuously but to a small extent during periods when the Swift No. 1 units are on Automatic Generation Control (AGC).

The changes in peak energy associated with alternative allowable daily level fluctuations in the Swift Reservoir are shown in Figure 3.1-1. The changes in peak energy shown reflect the net total change to the Lewis River system. Note that allowable daily level fluctuations of less than 1 foot reduce the Lewis River projects' peak period energy.

The upgrade evaluations described in the following sections are based on the historical flows for water year 1991 (the median year). As a result, the seasonal drawdown and refill of the Swift Reservoir (as well as the Yale Reservoir and Merwin Lake) that actually occurred in 1991 are automatically accounted for in the upgrade evaluations. This upgrade study does not consider new seasonal operating policies for any of the Lewis River reservoirs.

3.2 Water Delivery System Upgrades

The existing intake, tunnel, and penstock capabilities at Swift No. 1 are more than adequate to accommodate all of the turbine and electrical equipment upgrades considered. As a result, upgrade alternatives for these features of the water deliver system were not developed.

The existing capability of the Swift No. 1 surge tank is described in Section 2.1.2. Note, however, that the capability depends on the assumed freeboard for the plant full-load

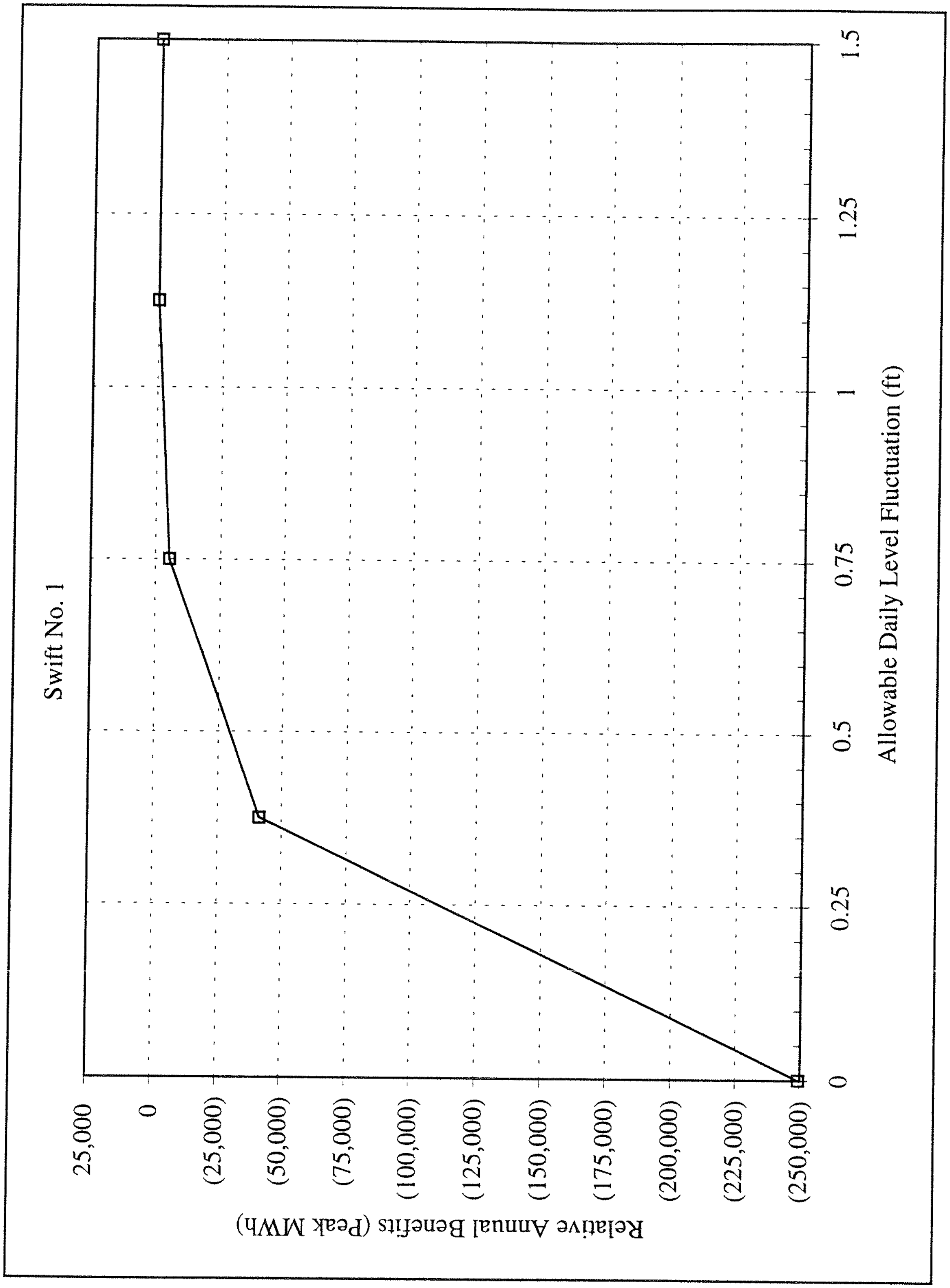

Figure 3.1-1. Peak energy impacts of alternative allowable daily level fluctuations in the Swift Reservoir.

rejection with the existing turbines. The actual water level rise in the surge tank under such conditions is not known.

In determining the existing surge tank capability, study engineers assumed that existing freeboard during a plant full-load rejection is approximately10 feet. If the actual existing freeboard is less than 10 feet, or if the plant hydraulic capacity exceeds the surge tank overload capability provided in Section 2.1.2, the surge tank will overtop.

In determining the energy benefits of Swift No. 1 upgrades, study engineers have not limited the maximum plant flow to the assumed overload capacity of the surge tank. Instead, study engineers have identified those upgrade options which would likely result in the surge tank overtopping. Depending on the extent of overtopping that actually occurs (if at all) with the most economic upgrades, the base of the tank and/or the area immediately adjacent to the tank may need to be armored for protection against the surge tank discharge.

Based on the current analyses, the cost of the electrical equipment upgrades required to increase the Swift No. 1 hydraulic capacity beyond the existing overload capacity of the surge tank are prohibitive. As a result, surge tank upgrade costs were not developed for those upgrade options which might result in overtopping the tank.

3.3 Turbine-Generator Upgrades

3.3.1 Rationale

In order to determine the manner in which PacifiCorp has historically operated the Lewis River system (and presumably will continue to operate), study engineers examined historical operating records from approximately 1980 through 1995. This period is generally drier than normal for the Lewis River basin. As a result, study engineers concentrated on the median year (water year 1991) data.

The Lewis River projects very rarely spill (less than 5 percent of the time during the overall period examined, including the median year). Available storage in the Swift Reservoir, Yale Lake, and Lake Merwin is apparently sufficient to regulate typical shortterm storm events and seasonal high runoff. Swift No. 1 and Swift No. 2 (and Yale) are generally operated as peaking plants; historical records indicate that the Swift No. 1 units generated 18 hours or less during 50 percent of the days examined. Also, the Swift No. 1 units regularly operate by Automatic Generation Control (AGC), during which they follow PacifiCorp's system load demands.

The Swift No. 1 upgrade alternatives were selected to examine the benefits of increased generating efficiency and the benefits of improved peaking operation through combinations of capacity increases at Swift No. 1 and Swift No. 2.

3.3.2 Turbine Upgrade Alternatives

Study engineers identified 2 alternatives for Swift No. 1. Alternative 1 is intended to increase on-peak and total generation by improving the maximum generating efficiency without changing the hydraulic capacity. Since the Swift No. 1 units regularly operate on AGC, a broad efficiency range is as important as the peak efficiency for the these units. Target performance characteristics for Alternative 2 were selected to increase the capacity to approximately the acceptable overload of the existing Swift No. 1 generators. This option is also intended to nearly match the three unit, peak efficiency flow at Swift No. 1 with the upgraded two unit full-gate hydraulic capacity of Swift No. 2. The desired performance characteristics for these alternatives are as follows:

Alternative 1. Best efficiency near 2,800 cfs, hydraulic capacity of approximately 3,050 cfs.
Alternative 2. Best efficiency near 3,070 cfs, hydraulic capacity of approximately 3,350 cfs.

Note that the hydraulic capacity expected by turbine manufacturers for each of these alternatives exceeds the target hydraulic capacity described above. Although the Alternative 2 runner described above is the highest capacity alternative investigated to date, turbine manufacturers estimate that additional hydraulic capacity (up to 3,800 cfs) is achievable with a deeper lower band and modified discharge ring.

3.3.2.1 Turbine Upgrade Performance

Performance data provided by American Hydro for the turbine upgrade alternatives are summarized in Table 3.3-1. Performance data are shown graphically in Figure 3.3-1. Note that the Swift No. 1 turbines' hydraulic designs are identical and, as a result, the upgrade performance characteristics are independent of the unit under consideration.

Table 3.3-1. Expected performance data for the Swift No. 1 turbine upgrade alternatives at 378 feet net head.

Alternative 1 "Low Flow"			Alternative 2 "High Flow"		
Flow (cfs)	Generator Output (kW)	Net Turbine-Generator Efficiency	Flow (cfs)	Generator Output (kW)	Net Turbine-Generator Efficiency
874	20,140	72.0%	963	22,120	71.8%
972	23,140	74.4%	1,070	25,390	74.1%
1,068	26,110	76.4%	1,176	28,670	76.2%
1,163	29,110	78.2%	1,280	31,950	78.0%
1,256	32,110	79.9%	1,382	35,230	79.6%
1,347	35,070	81.4%	1,483	38,510	81.1%
1,438	38,070	82.7%	1,582	41,770	82.5%
1,528	41,060	84.0%	1,681	45,050	83.7%
1,617	44,040	85.1%	1,779	48,320	84.9%
1,706	47,030	86.1%	1,877	51,610	85.9%
1,794	50,010	87.1%	1,974	54,880	86.9%
1,882	52,990	88.0%	2,071	58,170	87.8%
1,970	55,970	88.8%	2,168	61,450	88.6%
2,058	58,960	89.5%	2,264	64,710	89.3%
2,146	61,950	90.2%	2,361	67,990	90.0%
2,234	64,930	90.8%	2,458	71,270	90.6%
2,323	67,920	91.3%	2,556	74,550	91.1%
2,413	70,900	91.8%	2,655	77,830	91.6%
2,504	73,880	92.2%	2,755	81,100	92.0%
2,597	76,870	92.5%	2,857	84,360	92.3%
2,693	79,860	92.7%	2,963	87,670	92.4%
2,792	82,860	92.7%	3,071	90,920	92.5%
2,894	85,820	92.7%	3,184	94,200	92.4%
3,002	88,810	92.4%	3,303	97,480	92.2%
3,117	91,810	92.0%	3,429	100,760	91.8%
3,239	94,790	91.4%	3,563	104,030	91.2%
3,371	97,780	90.6%	3,709	107,320	90.4%
3,511	100,750	89.7%	3,864	110,600	89.4%

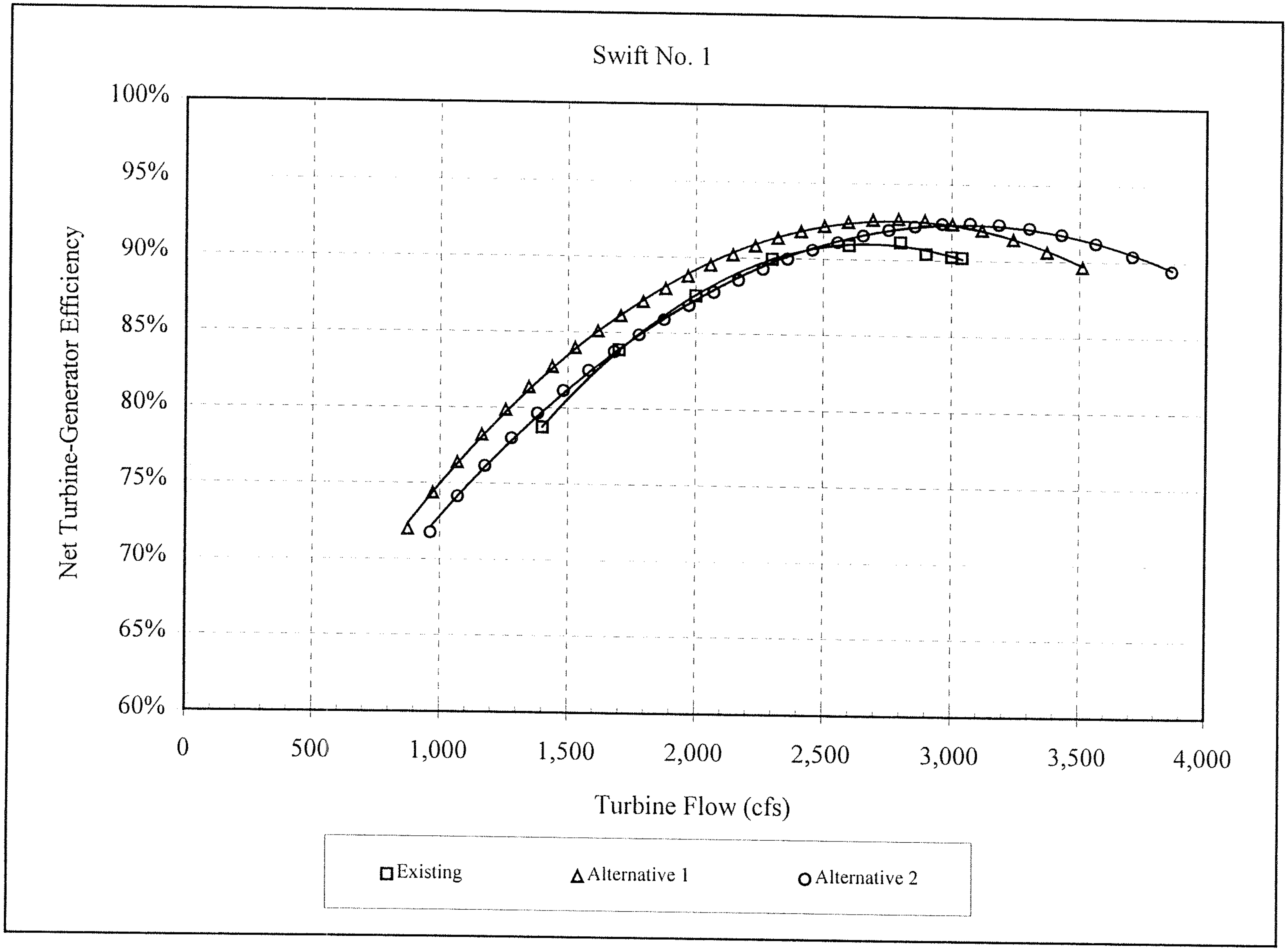

Figure 3.3-1. Performance data for the Swift No. 1 turbine upgrade alternatives at 378 feet net head.

3.3.2.2 Turbine Upgrade Costs

Turbine manufacturers did not inspect the Swift No. 1 units; the condition of existing runners is unknown. Turbine manufacturers recommend replacing the original runners with new runners of modern design and materials to optimize plant output. Coincident with the runner replacement, the wearing components such as the stationary wear rings, gate linkage bushings and pins, gate stem bushings, shaft packing and facing plates should be thoroughly cleaned, inspected and replaced as necessary. The following embedded and removable component rehabilitations are also recommended:

- Sandblast, clean, test, and paint the spiral case, stay vanes and draft tube liner.
- Sandblast, clean, test and paint the headcover, discharge ring and draft tube.
- Line bore and fit the headcover and bottom ring gate stem holes with new bronze or self-lubricating bearings.
- Fit and machine the wear rings and facing plates.
- Clean and test the wicket gates. Remachine the gate ends, seals, and bearing area. Sandblast, repair any surface damage on, and paint the gate leafs. As an alternative, the gates may be replaced at a cost comparable to their rehabilitation. Note that the existing gates have a modern profile. Consequently, new gates will not enhance the units' performance.
- Clean and test the turbine shaft. If cracks in the shaft are discovered through nondestructive testing, the shaft should be replaced. If cracks are not revealed through testing, the bearing and packing areas should be true cut or sleeved as required.

The turbine costs are provided in Table 3.3-2. Note that the upgrade costs are the same, regardless of the alternative selected. Replacing instead of rehabilitating the gates (if necessary) should not significantly impact the total estimated upgrade cost.

Table 3.3-2. Turbine upgrade costs.

Description	Cost[1] ($)
New turbine runner	950,000
Disassembly and reassembly (field work)	265,000
Refurbish/replace turbine components	375,000
Total estimated cost	1,590,000

1. The costs shown are estimated by turbine manufacturers and do not include any contingencies. Study staff have requested Yale upgrade costs from PacifiCorp staff to help refine the upgrade costs estimates for Swift No. 1.

3.3.3 Generator Upgrade Alternatives

The stator winding temperature on the Swift No. 1 generators is controlled by water flow modulating values in the each generator's cooling water supply system. Options for increasing the capacity of the generators include:

- Operation with a higher allowable stator winding temperature;
- Improvement of the cooling system to provide higher capacity while maintaining the present stator winding temperature limit;
- Rewinding or replacing the generators.

These options are described in the following sections.

3.3.3.1 Operation with Higher Allowable Stator Temperatures

Based on the generator nameplate ratings (from the 1987 to 1991 rewinds) and the observed temperature rise characteristics of the machines, the units are capable of continuous operation at approximately 110,000 kW (at unity power factor) without exceeding the design temperature rise of 60°C. Under these conditions, the stator temperature would be approximately 100°C, a 20°C increase over the historical operating condition and a 10°C increase over the present limit.

In all cases, regular operation of the Swift No. 1 generators at higher temperatures will reduce the remaining life of the machines and may shorten the time until a rewind of the generators is required. The observed high temperature operation and elevated corona activity in the Unit 2 generator make the higher temperature operation of this machine significantly less attractive.

The purpose of this discussion is not to recommend operating the Swift No. 1 generators above the overload capabilities described in Section 2 of this report. The purpose of this discussion is to clarify that the Swift No. 1 generator overload capabilities are based primarily PacifiCorp's imposed operating limits. Increasing these operating limits would increase the generating capability of the machines at the cost of reductions in the generators' remaining useful lives.

In completing the upgrade evaluations described in Section 4, study engineers have assumed that PacifiCorp would not raise the Swift No. 1 temperature operating limits. Instead, study engineers have assumed that PacifiCorp would, if necessary, increase the generators' capabilities by one of the other upgrade options.

3.3.3.2 Cooling System Improvements

The Swift No. 1 generator cooling systems include modulating water flow control valves which adjust the cooling water flow rate to maintain the stator winding temperatures. PacifiCorp staff report that the cooling system is at its performance limit during warm weather conditions. In warm weather and with high generator loads, the existing modulating valves must be bypassed to maintain stator temperatures below 80°C. PacifiCorp plans to replace the existing control valves with larger valves in 1996 or 1997; this upgrade should increase the flow capacity and eliminate the need for manual bypass of the flow control valves. PacifiCorp staff also report that internal corrosion in the cooling water piping has reached the point where flow restrictions exist in the main supply piping.

Study staff expect that, after replacement of the control valves, a higher generator output will be possible in automatic operation while maintaining a stator total temperature of 80°C. Additional increases in cooling performance (and generator capability) would require:

- Replacing or epoxy relining the existing cooling water supply piping
- Replacing the generator air coolers with higher performance coolers, or adding additional cooling tubes to the existing coolers.
- Increasing the water flow available by modification or replacement of cooling water supply pumps.
- Making more of the existing pumping system's water supply available for the generators by replacing the water cooled transformers on units 2 and 3 (as was recently done for Unit 1).

A heat rise test which includes measurement of the cooling water flows and temperatures is required to determine how much improvement is possible with these options. Based on the current reported operating conditions, study engineers expect that a 15 percent increase in the air cooler capacity would allow an approximate 5 percent increase in the electrical power capacity of each generator, without increasing the stator winding temperature. Note that this upgrade may not be feasible on Unit 2 due to the apparent corona activity problem in the existing generator.

3.3.3.3 Generator Rewinds

According to PacifiCorp staff, rewinds of the Swift No. 1 generators between 1987 and 1991 did not include strengthening the structural components such as the shafts, rotor spiders, pole assemblies or stator frames. Rewinding the generators to 110,000 kVA represents an increase of 46 percent over the original manufacturer's rating. Study staff consider this near the maximum practical limit for an upgrade without replacement or major strengthening of the stator frame. Rewinds which increase the capacity by more than 50 percent of the original rating may necessitate structural modifications to avoid over-stressing the structural components of the machines.

New generator cores and stator frames would be required achieve the capacity available from the largest turbine upgrade alternative investigated (approximately 116,000 kW). The cost of new generator cores and stator frames is considered prohibitive. Therefore, study engineers selected a 110,000 kVA capacity as the maximum which could be achieved with a "conventional" generator rewind. Study engineers expect that this capacity may be achieved without major structural changes to the generators.

3.3.4 Generator Upgrade Costs

The cost of relining or replacing the cooling water piping is difficult to estimate as the extent of corrosion blockage in the system is unknown. The corrosion blockage may be limited to the system supply piping downstream of the pump header and external to the unit air housing. However, the cooling system corrosion blockage may also extend into the generator air cooler supply piping within the air housing. These conditions could double the cost of a pipe relining or replacement program.

The cost of replacing the air coolers on the Swift No. 1 higher capacity coolers is shown in Table 3.3-3. These costs include an allowance for relining the cooling water supply piping external to the generator air housings.

The cost for rewinding the generators to the maximum feasible rewind rating is shown in Table 3.3-3 This cost range assumes a 20 percent allowance for limited structural modifications of the generators (over the base cost of the stator rewind). Budgetary estimates to achieve for a 116,000 kVA generator rating shown in Table 3.3-3 include a new generator stator frame, core, rotor shaft and auxiliaries.

Table 3.3-3. Swift No. 1 generator upgrade ratings and estimated costs.

Description	Capacity at Unity Power Factor (each unit)		Upgrade cost ($)
	Existing (kW)	Upgraded (kW)	
Cooling system upgrade	95,000 (overload, units 1 & 3) 85,000 (derated, unit 2)	100,000 (units 1 & 3) 89,000 (unit 2)	80,000
Generator Rewind	95,000 (overload, units 1 & 3) 85,000 (derated, unit 2)	110,000	1.8 to 2.4 million
Generator Rewind	95,000 (overload, units 1 & 3) 85,000 (derated, unit 2)	116,000	5 to 7 million

3.4 Generator Bus Upgrades

3.4.1 Upgrade Alternatives

Operation above the existing bus duct rating would require replacement of the bus conductor and bus links at the generator and transformers. The upgrade would consist of a new copper bus conductor with a larger cross sectional area, but with the same 6-inch by 6-inch external conductor dimensions. No modification of the bus housing is considered necessary. The bus rating could be increased to accommodate a generator either of the generator rewind alternatives investigated (with and without structural modifications).

3.4.2 Upgrade Costs

Upgrade costs for the generator bus upgrades are shown in Table 3.4-1.

Table 3.4-1. Generator bus upgrade ratings and costs.

Description	Capacity at Unity Power Factor (each unit)		Upgrade cost[1] ($)
	Existing (kW)	Upgraded (kW)	
Bus replacement	105,000	110,000	40,000
Bus replacement	105,000	116,000	40,000

1. Cost estimates are based on a total bus length of 70 feet with three 90 degree elbows and bus links at each end of the bus

3.5 Transformer Upgrades

3.5.1 Upgrade Alternatives

The Swift No. 1 Unit 1 transformer was rewound and retrofit with a FA/FO air cooling kit following a failure in 1995. This upgrade resulted in a higher nameplate rating than the Unit 2 or Unit 3 transformers. The Unit 2 and Unit 3 transformers windings are original. Achieving a capability that matches the rewound generator capability on any of the units requires rewinding the transformer on that unit. Transformer rewinds on either Unit 2 or Unit 3 would also include the addition of new air cooling kits, similar to the kit installed on Unit 1 in 1995.

Access rails to each transformer run "through" the footprint of the adjacent land-side transformers. As a result, rewinding the Unit No. 2 or Unit No. 3 transformers would require taking the adjacent land-side transformers out of service. A rewind of the Unit No. 2 transformer, for example, would require taking the Unit No. 1 transformer out of service twice - once for removal of the Unit No. 2 transformer and once later for reinstallation of the Unit No. 2 transformer. A rewind of the Unit No. 3 transformer would similarly require two outages of both units no. 1 and no. 2 - essentially a full plant outage during both removal and reinstallation of the Unit No. 3 transformer. Alternatively, in the event of a Unit No. 3 transformer failure and/or upgrade, all three transformers could be taken out of service and the two working transformers placed in the Unit No. 3 and Unit No. 2 transformer locations (leaving the Unit No. 1 transformer location open). This scheme would eliminate the second outage, but the feasibility of this option should be confirmed (the feasibility depends in part on the similarity of the cooling arrangements).

Study staff do not believe that upgrading either the Unit No. 2 or Unit No. 3 transformers with FA/FO kits would measurably increase the capability of these transformers above their existing overload capability.

3.5.2 Upgrade Costs

Study staff estimated the cost for upgrades of the Unit No. 1 and Unit No. 3 transformers based on PacifiCorp's recent experience on Unit No. 1 and industry standard cost data. The cost of the 1995 upgrade of the Unit No. 1 transformer was $500,000. Transformer upgrade costs on either of the other units would be similar but slightly higher depending on the desired rating. Also, the Unit No. 2 or Unit No. 3 upgrade costs include allowances for the additional cost of removing adjacent transformers for access. Transformer upgrade costs are shown in Table 3.5-1. These costs do not include outage costs. Also, no lost energy or capacity costs for potential flow reductions at Swift No. 2 are included in these figures.

Study staff developed upgrade costs for the Unit No. 1 transformer even though it was recently rewound. Estimated costs for rewinding the Unit No. 1 transformer to an even higher rating would be lower than the costs on units no. 2 or no. 3 since Unit No. 1

already has a modified cooling kit and rewinding this transformer does not require an outage of any other unit.

Table 3.5-1. Transformer Upgrade ratings and costs.

Description	Unit	Capacity at Unit Power Factor		Upgrade cost ($)
		Existing (kW)	Upgraded (kW)	
Rewind and cooling kit addition	1	100,000 (overload)	110,000	436,000
	2	91,350 (overload)	110,000	544,000
	3	91,350 (overload)	110,000	574,000
1. Not including lost energy or outage costs for Swift No. 1 or Swift No. 2.				

4.0 UPGRADE EVALUATIONS

4.1 Upgrade Options

Potential changes in the Swift No. 1 generation capability associated with turbine, waterway, and electrical equipment upgrades are shown in Figure 4.1-1. The range of options investigated are described below. Note that the existing condition and capability of units no. 1 and no. 3 are essentially the same. The upgrade evaluations assume that Unit No. 1 is upgraded first (since the transformer has already been upgraded).

Existing Capability: The existing capability of the existing features and equipment at Swift No. 1. The existing development capability is limited by the three unit, full gate turbine-generator output.

Option 1: This option consists of replacing the existing Unit No. 1 runner with a new low flow (Alternative 1) runner. The capability of Swift No. 1 under these conditions is limited by acceptable generator overload on Unit No.1 and the existing full-gate turbine-generator output on units no. 2 and no. 3. Note that the intake/tunnel, surge tank and Unit No. 1 penstock all operate above their current maximum flow (but within the acceptable overload) under these conditions.

Option 2: This option includes replacing the existing Unit No. 1 and Unit No. 3 runners with new low flow (Alternative 1) runners. The capability of Swift No. 1 under these conditions is limited by acceptable generator overload on Unit No. 1, the existing full-gate turbine-generator output on Unit No. 2, and acceptable transformer overload on Unit No. 3. As with Option 1 and all of the following options, the intake/tunnel, surge tank and Unit No. 1 penstock all operate above their current maximum flow (but within the acceptable overload).

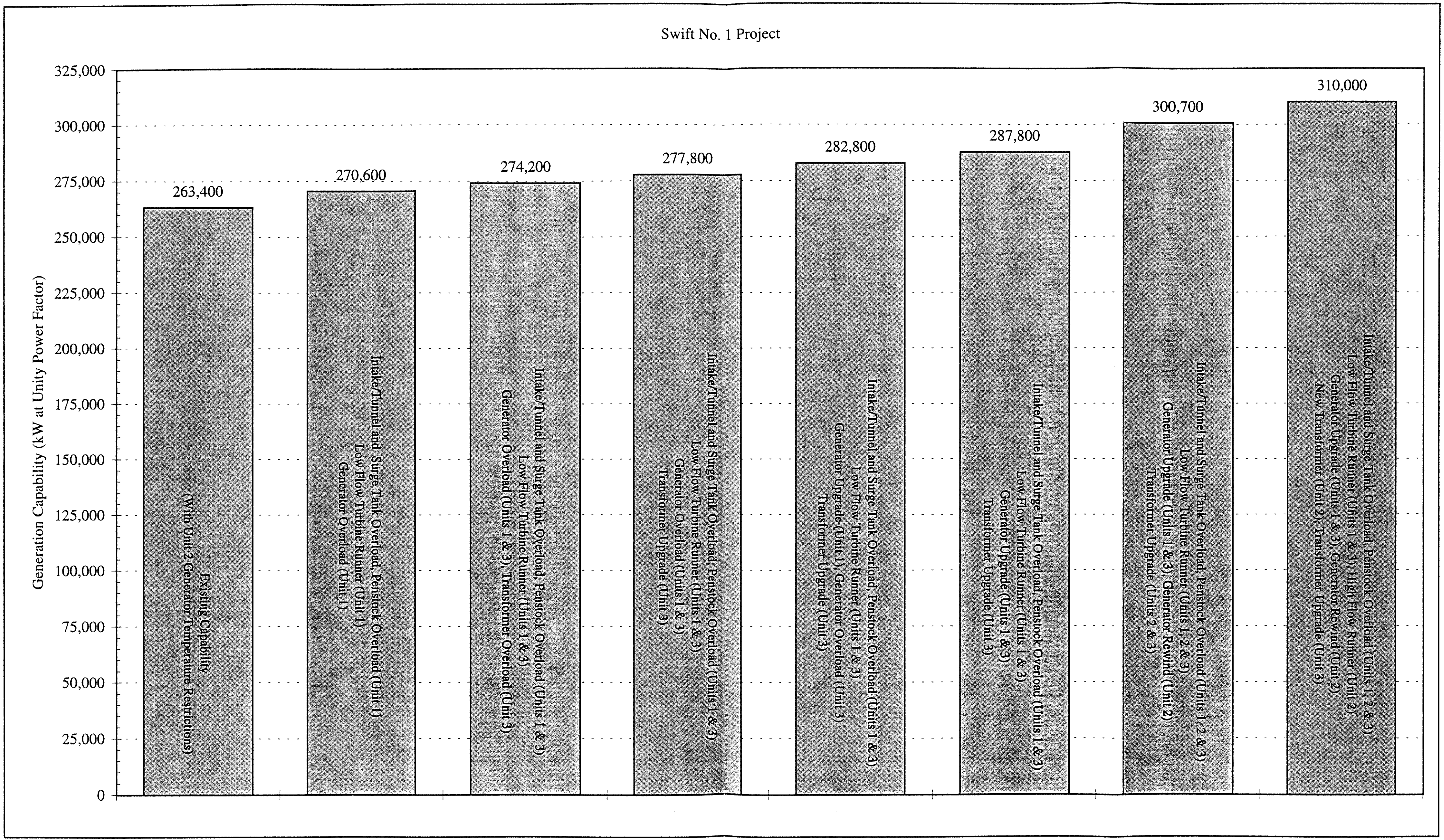

Figure 4.1-1. Potential increases in the Swift No. 1 generation capability.

Option 3: This option includes replacing the existing Unit No. 1 and Unit No. 3 runners and upgrading the Unit No. 3 transformer. The plant generation capability is limited by the acceptable generator overload on units no. 1 and no. 3, and the existing full-gate turbine-generator output on Unit No. 2.

Option 4: This option includes all the elements of Option 3 and a generator rewind on Unit No. 1. The generator rewind is well-matched to the upgraded turbine capacity. The plant generation capability is limited by the rewound generator capability on Unit No. 1, the existing turbine-generator capability of Unit No. 2, and the acceptable generator overload on Unit No. 3.

Option 5: Option 5 is very similar to Option 4, but with the addition of a generator rewind on Unit No. 3. The plant generation capability is limited by rewound generator capability on units no. 1 and no. 3, and the existing capability of Unit No. 2.

Option 6: Option 6 includes all the Unit No. 1 and Unit No. 3 upgrades of Option 5. This option also includes a new low flow turbine runner and a transformer upgrade on Unit No. 2. Note that the Unit No. 2 electrical equipment upgrades included in this option are required to realize the benefits of the new turbine runner. Also, the Swift No. 1 surge tank may overtop during a plant full load rejection with all of these upgrades. The plant generation capability is limited by rewound generator capability on all three units.

Option 7: This is the highest capacity option investigated. It includes new low flow (Alternative 1) turbine runners and transformer upgrades on units no. 1 and no. 3, and an upgrade of Unit No. 2 that includes a new high flow (Alternative 2) runner, a generator rewind, bus upgrade, and transformer upgrade.

4.2 Upgrade Evaluations

The matrix of upgrade options investigated at Swift No. 1 is shown in Table 4.2-1. Upgrade cost summaries are provided in Table 4.2-2. Note that the energy benefits of the upgrade options are shown relative to the existing condition. Also, the energy benefits shown reflect the net total benefits to the entire Lewis River system.

4.3 Economic Comparison of Upgrades

Note the relative annual energy benefits associated with abandoning the stator winding temperature limit on Swift No. 1 Unit No. 2. This information is provided to help PacifiCorp determine whether the costs of derating this unit are sufficient to offset the benefit. The benefit of this derating is that it may significantly delay the costs of rewinding this unit.

Based on the upgrade evaluations shown in Table 4.2-1, the most economic upgrade at Swift No. 1 includes replacing the Unit No. 1 runner with a new runner similar to Alternative 1 (with a peak efficiency flow near 2,800 cfs and a hydraulic capacity of approximately 3,500 cfs). This upgrade option is shown as Option 1 in Table 4.2-1. A second upgrade with similar economic benefits to Option 1 is Option 3. Note that this option includes the same upgrades to Unit No. 1 and Option 1, but also includes a similar new (Alternative 1) turbine runner and a transformer upgrade on Unit No. 3. Note that the Unit No. 3 transformer should be upgraded coincident with the Unit No. 3 runner replacement (if this Option is implemented). Replacing the transformer allows more of the unit's upgraded hydraulic capacity to be used.

4.4 Upgraded Project Capability

The Swift No. 1 Unit No. 1, Unit No. 2, and Unit No. 3 upgraded capabilities are shown in Figures 4.4-1, 4.4-2, and 4.4-3, respectively. The upgraded capability diagrams reflect the components of upgrade Option 3 in Table 4.2-1.

Table 4.2-1. Swift No. 1 upgrade options.

	Swift 11							Swift 12							Swift 13								Swift No. 1 Capability		Costs	Relative Annual Benefits (MWh)		
Option	Swift 11 Existing Runner	Swift 11 Alt. 1 Runner	Swift 11 Alt. 2 Runner	Swift 11 Generator Cooling System Upgrade	Swift 11 Generator Rewind	Swift 11 Bus Upgrade	Swift 11 Transformer Upgrade	Swift 12 Existing Runner	Swift 12 Generator Overload	Swift 12 Alt. 1 Runner	Swift 12 Alt. 2 Runner	Swift 12 Generator Rewind	Swift 12 Bus Upgrade	Swift 12 Transformer Upgrade	Swift 13 Existing Runner	Swift 13 Alt. 1 Runner	Swift Alt. 2 Runner	Swift 13 Generator Cooling System Upgrade	Swift 13 Generator Rewind	Swift 13 Bus Upgrade	Swift 13 Transformer Upgrade	Surge Tank Overtopping (estimated)	Hydraulic Capacity (cfs)	Capability (kW)	Total Upgrade Costs ($)[1]	Peak	Off-Peak	Total
Existing Condition	X							X							X								9,120	263,400	0	0	0	0
Option 1		X						X							X								9,330	270,600	1,590,000	2,100	1,100	3,200
Option 2		X						X								X							9,390	274,200	3,180,000	4,500	1,900	6,400
Option 3		X						X								X					X		9,540	277,800	3,754,000	5,500	2,400	7,900
Option 4		X		X				X								X					X		9,760	282,800	3,834,000	8,100	4,000	12,100
Option 5		X		X				X								X		X			X		9,990	287,800	3,914,000	13,300	5,600	18,900
Option 6		X		X						X		X		X		X		X			X	X	10,460	300,700	8,448,000	12,200	5,600	17,800
Option 7		X		X							X	X	X	X		X		X			X	X	10,790	310,000	8,488,000	15,500	7,000	22,500

Table 4.2-2. Swift No. 1 upgrade cost details.

	Swift 11				Swift 12				Swift 13				
Option	**Unit 1 Turbine Costs ($)**	**Unit 1 Generator Upgrde Cost ($)**	**Unit 1 Bus Upgrade Cost ($)**	**Unit 1 Transformer Upgrade Cost ($)**	**Unit 2 Turbine Costs ($)**	**Unit 2 Generator Upgrade Cost ($)**	**Unit 2 Bus Upgrade Cost ($)**	**Unit 2 Transformer Upgrade Cost ($)**	**Unit 3 Turbine Costs ($)**	**Unit 3 Generator Upgrade Cost ($)**	**Unit 3 Bus Upgrade Cost ($)**	**Unit 3 Transformer Upgrade Cost ($)**	**Total Upgrade Cost ($)**
Swift 12 Generator Overload													0
Option 1	1,590,000												1,590,000
Option 2	1,590,000								1,590,000				3,180,000
Option 3	1,590,000								1,590,000			574,000	3,754,000
Option 4	1,590,000	80,000							1,590,000			574,000	3,834,000
Option 5	1,590,000	80,000							1,590,000	80,000		574,000	3,914,000
Option 6	1,590,000	80,000			1,590,000	2,400,000		544,000	1,590,000	80,000		574,000	8,448,000
Option 7	1,590,000	80,000			1,590,000	2,400,000	40,000	544,000	1,590,000	80,000		574,000	8,488,000

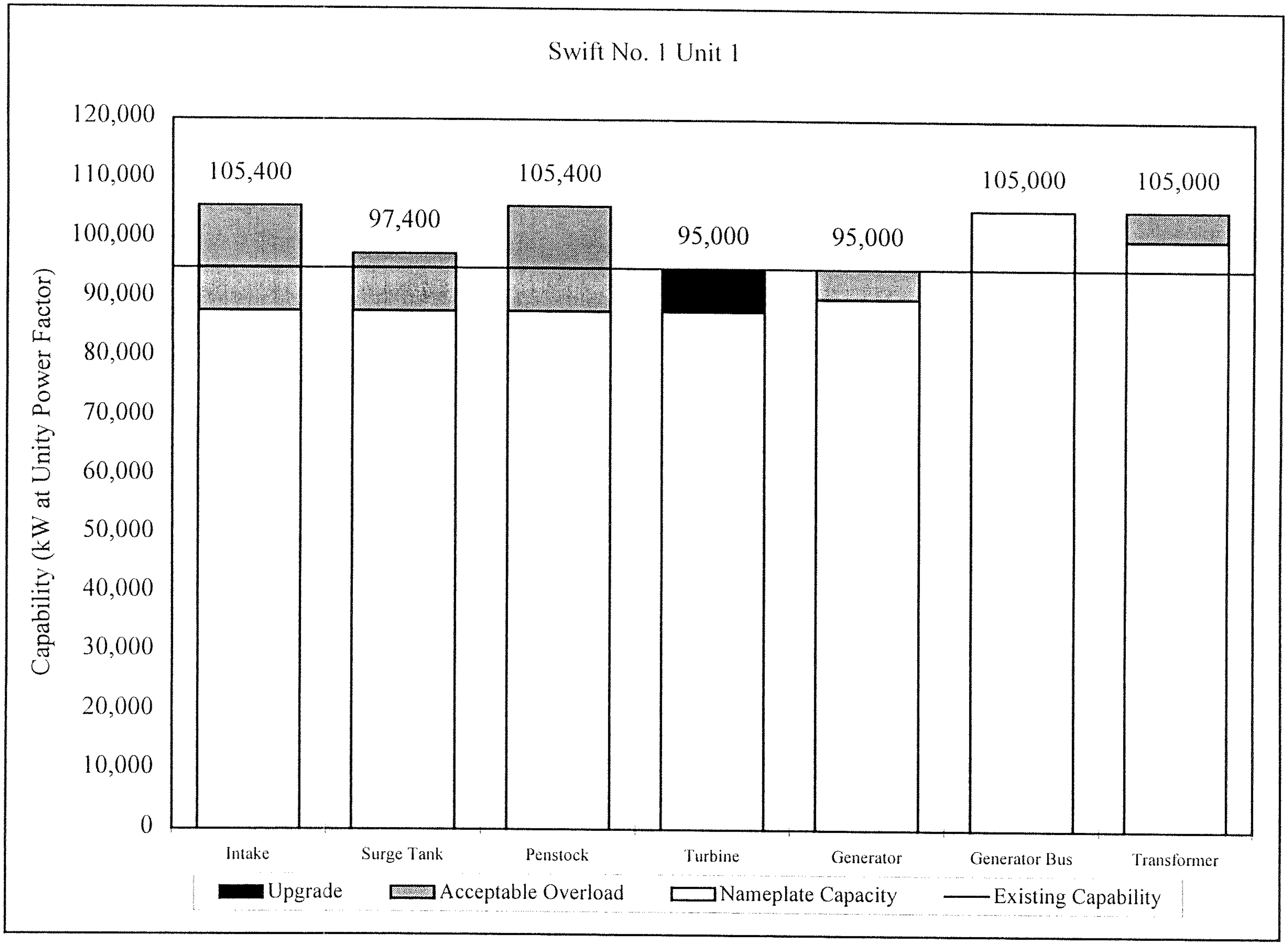

Figure 4.4-1. Upgraded Swift No. 1 Unit 1 generation capability.

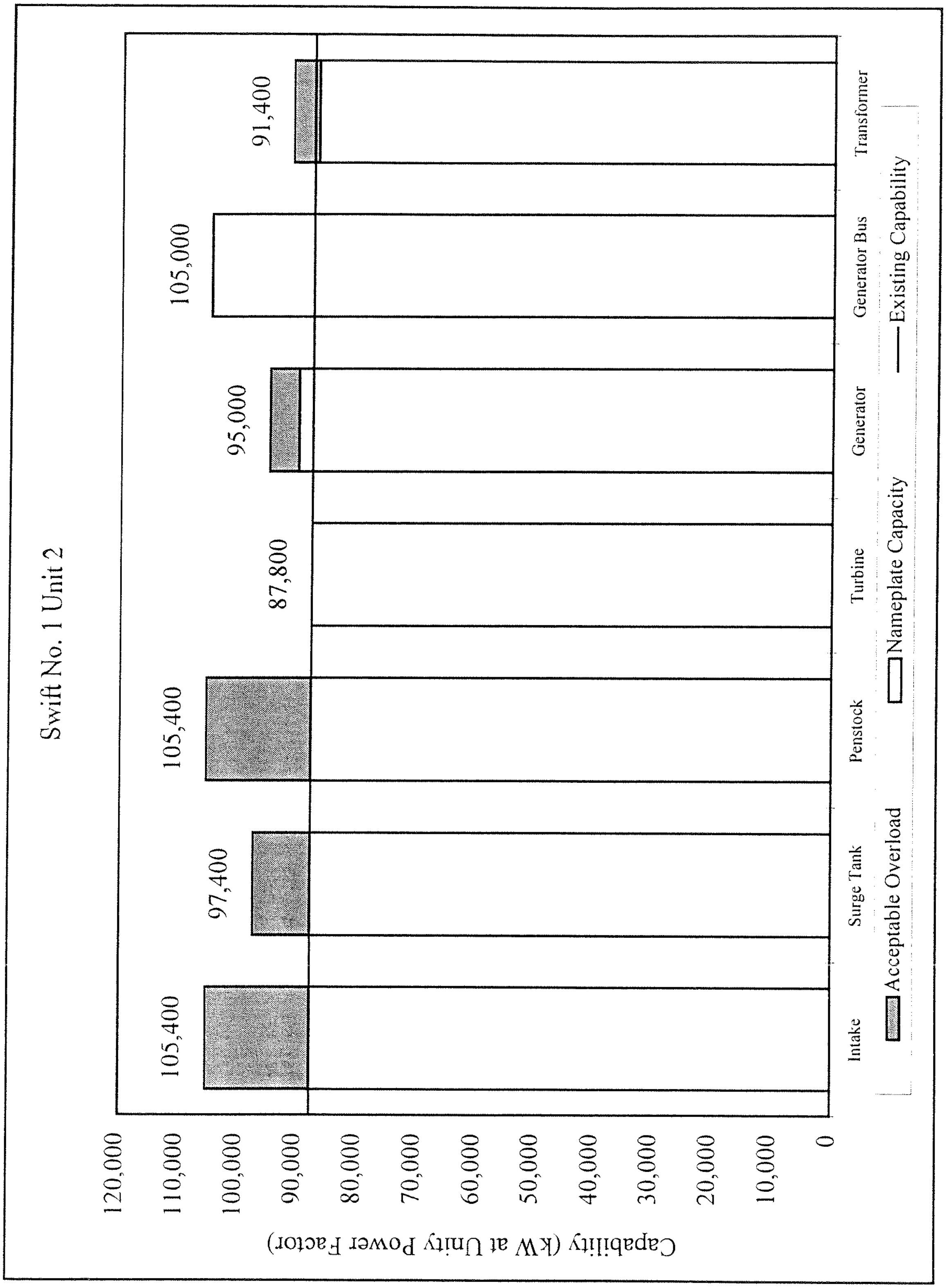

Figure 4.4-2. Existing Swift No. 1 Unit 2 generation capability (no change).

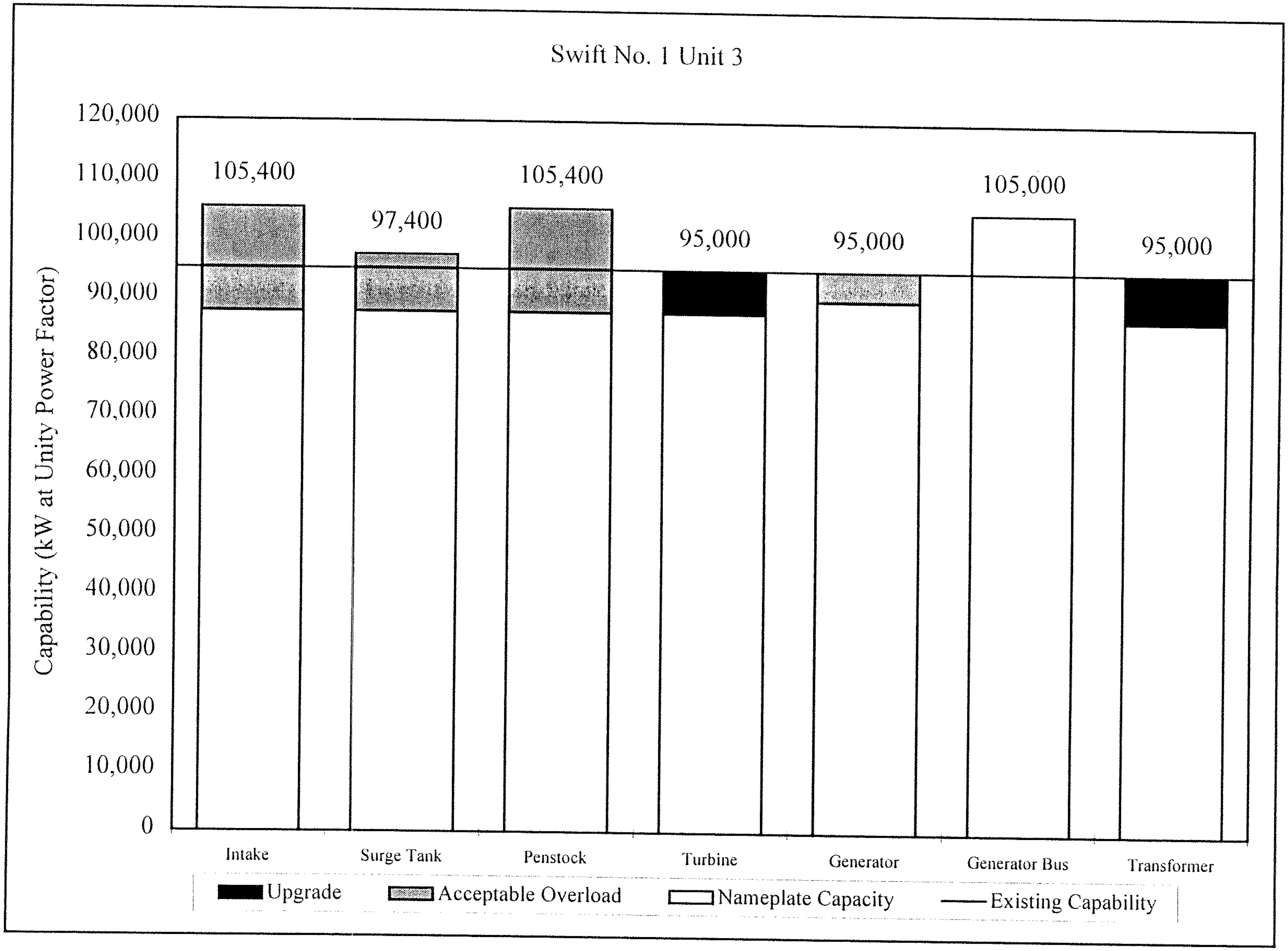

Figure 4.4-3. Upgraded Swift No. 1 Unit 3 generation capability.